THE LEGACY OF HIROSHIMA

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INTRODUCTION

THE CATASTROPHE of World War II could have been avoided. If we had not pressed for reparations after World War I, if we had used foreign aid as we are now using it, Hitler might never have come to power. If we had supported the League of Nations as we now are supporting the United Nations, lawless conquest would not have become rampant in the 1930s. If we had spent as much on military preparedness as we now are spending, Hitler could have been defeated in the first year of the war.

But what would have sufficed a few decades ago is not enough today. The world has become smaller; time has become shorter; changes and revolutions have become more frequent. And in Russian Communism we have met an opponent that is more powerful, more patient, and incomparably more dangerous than German Nazism.

What we are doing today would have seemed impossible in 1930. What we actually should be doing, similarly, seems beyond our reach at present. By being one generation behind our times, we are endangering peace; we may bring about World War III.

It has become necessary to create a lawful world community. Most people agree that our globe has become too small, too crowded, too dangerous to accommodate many sovereign governments—each of them a law unto itself. This is the chief obstacle to peace, the central problem of the world today. It is futile to

present a blueprint for the solution of this problem; it cannot be solved at one stroke. The solution requires many contributions from many quarters.

The main purpose of this book is to make my contribution to the cause of peace. I shall not limit myself to a single aspect of this problem. How to teach science, how to use science to conquer misery and provide more stability are questions that must be discussed and can be discussed in the spirit of hope.

Owing to my experience in the field of atomic explosives, it is proper that I should particularly emphasize the influence that these powerful instruments have on all questions of war and peace. One fact seems inescapable to me: It will not be possible to preserve peace unless we are willing to think carefully and in detail about war.

My contention is not that our preparation for war is insufficient. My main point is that our preparation is misdirected. We have been frightened by the display of our own power at Hiroshima, and we have lost our sense of proportion. On the one hand, we think of an all-out war as a cataclysm that will wipe out mankind. On the other hand, we think of an abolition of nuclear weapons as a means to restore stability and to avoid a future war. These two patterns of ideas are driving us toward a tragedy which, when it comes, will be of our own making.

There are a few points which are obvious, but which are rejected by the majority of our people.

In a dangerous world we cannot have peace unless we are strong.

We cannot be strong unless we are fully prepared to exploit the biggest modern power, nuclear explosives.

Nuclear weapons can be used with moderation on all scales of serious conflict. Nuclear weapons do not mean the end of the world, but they do mean the end of non-nuclear power.

World War III would be much worse than anything we can remember. But it would not destroy mankind. If we do not

prepare, it would do to us what wars have done to many nations. It would kill the United States.

The atomic age has brought fears, and it has brought a challenge. Unless we respond to the challenge, unless we create a world of tomorrow better than anything we can imagine or describe, too many of our fears will be justified.

The validity of these statements should be evident. Talking with my friends, reading books and newspapers, listening to the speeches of politicians and scientists have convinced me that the opposite of some of these statements is widely believed and that none of them are fully accepted. That is why these statements have been expanded into a book.

None of these statements can be proved. The world is much more involved than a mathematical demonstration. And, outside of mathematics, it is too often possible to prove both a statement and its opposite. So I shall not attempt to prove. I can only describe and discuss.

Much of the description will be personal. I am eager to state both my reasons and my motives. Much of the discussion will be detailed. Familiarity does help understanding, and details slow us down enough to prevent us from making false generalizations. Some of the conclusions will be erroneous; in discussing difficult questions, this is unavoidable. Yet I am fully convinced of the correctness of my statements, and I will present my conclusions in terms of my own full convictions.

a fantastic amount of energy. The question was whether a splitting nucleus would create more neutrons, and the answer to this question was important. Said Szilard: "Hitler's success could depend on it."

A few weeks later I was at my piano, attempting with the collaboration of a friend and his violin to make Mozart sound like Mozart, when the telephone rang. It was Szilard, calling from New York. He spoke to me in Hungarian, and he said only one thing: "I have found the neutrons." I was unhappy about those neutrons. They presented, to me, an inescapable challenge. I guessed, then, that I would be unable to continue playing with theories.

Later that summer I was given my first atomic assignment. I was drafted as chauffeur for Szilard, who never had descended to the mechanical skill of driving a car. He had an appointment with Albert Einstein at Peconic Bay, N.Y., that was to have a profound effect on the future of the United States. It was August 2, 1939, and during their meeting Szilard and Einstein discussed a letter addressed to "F. D. Roosevelt" at the White House. It read:

> Sir:
>
> Some recent work by E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future.
>
> Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:
>
> In the course of the last four months it has been made probable —through the work of Joliot as well as Fermi and Szilard, in America—that it may become possible to set up a nuclear chain reaction in a large mass of uranium, by which vast amounts of power and

large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable—though less certain—that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might well prove to be too heavy for transportation by air.

The United States has only very poor ores in uranium in moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an unofficial capacity. His task might comprise the following:

A—To approach Government departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States.

B—To speed up the experimental work, which at present is being carried on within the limits of the budgets of university laboratories, by providing funds, if such funds are required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German under-secretary of state, Von Weizsacker, is attached to the Kaiser-Wilhelm Institute in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,

test site. We were told to lie down on the sand, turn our faces away from the blast, and bury our heads in our arms. No one complied. We were determined to look the beast in the eye.

But, having practiced to expect the impossible, I was cautious. Beneath the welder's glasses provided us, I wore an extra pair of dark glasses. I smeared my face with sun-tan lotion and offered some to the others. I wore a heavy pair of gloves. Holding the welder's glasses securely to my face with both gloved hands, I converted the glasses into goggles.

The test, delayed ninety minutes by a desert rainstorm, was rescheduled for 5:30 A.M. Twenty minutes before, our observation post was tied in with the control center by radio. The count-down began: "It now is minus twenty minutes, nineteen minutes, eighteen minutes, seventeen minutes . . . It now is minus thirty seconds, twenty-five, twenty, fifteen." At ten, the count-down was second by second: "Nine . . . eight . . . seven . . . six . . . five." Then there was silence.

The five seconds of quiet stretched out until I thought the explosion had failed. I was almost ready to take off my protective glasses. But then, through the glasses, I saw a tiny pin point of light. I was disappointed: "Is this all? Is this what we have worked so hard to develop?"

In a second, I remembered that I was wearing a double thickness of dark glasses. The pin point of light grew and then faded. I tipped my right hand away from my face to allow a crack of light beneath my glasses. It was like opening the heavy curtains of a darkened room to a flood of sunlight. Then I was impressed.

In a minute, the explosion's noise and pressure wave reached us. William H. Lawrence, the well-known and competent science reporter, was alarmed: "What was that?"

I took off both pairs of dark glasses to watch the explosion's remarkable mushroom cloud swell into the atmosphere, stop when it hit a layer of warm air, and then shoot up again. As the cloud towered 40,000 feet above us, we trooped back toward our bus,

Fuchs' reserve seldom abandoned him, and he seldom attracted attention in a group. But he drew my notice at a certain Los Alamos dinner party in a way that later seemed significant. The dinner guests' excited conversation concentrated on that day's arrest of Allan Nunn May, a British physicist working in Canada, for giving atomic secrets to the Russians. Some of the dinner guests knew May and liked him. They could not believe he was a spy. Others maintained that we should not have been surprised, that spying had to be expected.

When we left the dinner party, I asked my wife what had been bothering Fuchs. His behavior, although not unusual, seemed to indicate that something was wrong. He had not argued with the others about May, but he never argued. He had remained silent, but he usually was silent. Still, it somehow seemed clear to Mici and me that of all the people at the party, Fuchs had been most deeply affected by May's arrest.

I neither defend nor excuse Fuchs' spying. But I am convinced that he spied because he thought he was doing the right thing for the country and the political philosophy that commanded his allegiance. Russia, however, found it difficult to believe that anyone would undertake the enormous risks of a spy only to satisfy his conscience. Fuchs did what he arrogantly thought was right, but Russia refused to accept this as a contribution to World Communism. Russia insisted on paying for his information. In the sordid story of Fuchs' spying, this payment was the most shameful episode. The Russian payments were trifling. The largest was $400. Fuchs, unmarried, did not need the money, but accepted it "as a symbol of subservience to Russia." The purpose of the Russians in paying anything at all was clear: If he were caught, Fuchs would be treated as a hired spy rather than as a Communist visionary.

When he was arrested in England in 1950, and sentenced to fourteen years in prison for his betrayal, Fuchs offered a coldly analytical explanation of how he had managed to circulate among us without being suspected: "I used my Marxian philosophy to

conceal my thoughts in two separate compartments. One side was the man I wanted to be. I could be free and easy and happy with other people without fear of disclosing myself, because I knew the other compartment would step in if I reached the danger point. . . . Looking back on it now, the best way is to call it a controlled schizophrenia."

Many Americans believe that Russia could not have produced an atomic bomb without the information supplied by Fuchs and other spies. This I doubt. From what I have seen of the competence of Russian scientists, I am positive they could have produced an atomic explosion with no outside help. But the knowledge that an atomic bomb actually could be produced, that it was a fact and not a mere theory, was a powerful spur to the Russian achievement. Hiroshima and Fuchs' information prompted the Kremlin to give full governmental support to Russian scientists working in nuclear physics, organizing Russia's atomic efforts to a degree that might not have been attained for years. Fuchs reported and Hiroshima proved to Russia that atomic success was possible.

If the spies did not make a Russian atomic bomb possible, they made it possible a little sooner. They contributed to the disappearance of our advantage. The United States still had some advantage when we proposed the Baruch Plan, but Russia already had the secrets we were proposing to share. This was the most important result of the work of Fuchs and his fellow spies, and this is the saddest part of their story: They effectively doomed the Baruch Plan that would have ensured world peace.

Americans did not seem to care. Thinking they had an atomic monopoly that experts insisted would continue for another twenty years, the American people pushed the problem of international controls aside. We did not bother to reinstate our atomic agreements with wartime allies. Despite the continuing and increasing Russian menace, we allowed nuclear unity between ourselves and other Western nations to disintegrate.

Our advantage began to fade.

Spies, the slowdown of our laboratories, the disintegration of information exchanges with our allies, and Russian stalling on the Baruch Plan—all co-operated to undermine our advantage. So did the exaggerated importance we placed on secrecy in the naïve belief that secrecy would ensure our atomic monopoly.

I vividly recall one postwar conference that I attended during a visit to Los Alamos from Chicago. The conference was with Air Force officials in Albuquerque. The purpose: To find out what kind of nuclear explosives the Air Force wanted us to develop.

We explained that the size of the two bombs already dropped by the Air Force had been influenced by the size of Air Force planes. They had to fit into a B-29. But, we explained, development of a variety of nuclear weapons was possible. They could be bigger, smaller, more or less powerful than the bombs dropped on Hiroshima and Nagasaki. We sought guidance: What were the Air Force requirements?

This conference lasted all of one day. To my astonishment, we could get only one answer: "The bomb we have now is precisely what we need." It became obvious during the day that few of the military men involved in the conference had any notion of how an atomic explosive worked, and even fewer had any concept of what future atomic explosions could accomplish.

What was the reason for this amazing lack of knowledge about atomic explosives and their capabilities? Was it a lack of imagination? A lack of interest? A lack of intelligence? Or was it, perhaps, secrecy?

None of us easily accepts new ideas. Human inertia makes us cling to the old. With secrecy preventing discussion of all new facts, it was only natural that the military men should accept, in our bizarre atomic world, only those changes they had to accept. The "bomb" was an unassailable fact and had to be accepted. But there was no opportunity, because of secrecy, and no incentive, because of inertia, to think further ahead.

I am firmly convinced that in the early postwar years secrecy was a powerful barrier between military men who were clinging

to the past and scientists who were turning away from what seemed a frightening future.

Despairing of getting any guidance from the Air Force officials in Albuquerque, we flew back to Los Alamos. On the way, Marshall Holloway, who then was in charge of weapons development at Los Alamos, remarked: "I never knew it was so difficult to find the horse's mouth."

In the summer of 1949, I was given a hint that our advantageous atomic position was about to vanish; but I did not recognize the hint.

I was in England attending a conference as chairman of the Atomic Energy Commission's first reactor safeguard committee. One evening I was invited to dine with the man who had the reputation of being the world's most silent nuclear physicist, Sir James Chadwick. According to his habit, Chadwick did not speak throughout the meal. Lady Chadwick, however, chatted gaily. Near the dinner's end, she inquired about mutual friends the Chadwicks had met at Los Alamos. She asked about General Leslie R. Groves, boss of the Manhattan Project. General Groves was not popular among scientists, and my reference to him was not particularly complimentary. I thought my remark was on safe social grounds, because Groves had been opposed to atomic cooperation with the British.

But my reference to Groves produced a most surprising reaction from Chadwick: He began talking. And he talked for an hour before I could get a word in edgewise. He insisted that Groves was most conscientious, that in high councils it was Groves rather than scientists who pressed for development of the atomic bomb, that it was Groves who had obviated unnecessary delays, that our strong international position was due to the efforts of Groves more than those of any other man, that he had given the United States a tremendous advantage.

Chadwick insisted on walking me to my hotel. He praised

Groves all the way. I protested: "Most scientists just couldn't get along with Groves, and he strongly opposed atomic co-operation with your own country."

Chadwick replied: "Yes, but he was a man of his word. He could be trusted. When he said he would do something, it was done."

I protested no more, but concentrated on Chadwick's unqualified praise of Groves. I knew there was some reason for the unexpected outburst; Chadwick never spoke without a reason. I decided that if a man of Chadwick's stature wanted to tell me something he considered important, I had better listen. At my door he took my hand and looked me squarely and seriously in the eye. He said: "I hope you will remember what I have said tonight."

Chadwick knew something which I did not yet know.

I sailed for the United States, and in a few days arrived for a briefing at the Pentagon.

During the briefing the officer in charge referred to something that everyone else in the room apparently had heard. He said: "Gentlemen, the President's announcement this morning was correct. It has been verified."

After the briefing I went to the front of the room and asked the officer: "What announcement?"

"You didn't hear it?"

"No."

"He said Russia has exploded an atomic bomb."

CHAPTER THREE:

The Hydrogen Bomb

FEW MODERN SCIENTIFIC achievements spring, full of life, from the mind of a single individual. Success demands teamwork. It depends upon hundreds of ideas and thousands of technical skills involved with conception and theory, a mass of detailed calculations and—finally—the actual engineering and construction of the device. Successful development of the hydrogen bomb in the United States was based on this kind of teamwork.

Another story, quite different and quite false, often is presented. A public apparently unprepared to grasp the enormous complexities of modern scientific-technical developments frequently is satisfied with outrageous oversimplifications. Too often only the name of a single individual is mentioned. People are left with the impression that he alone was responsible. This representation is both untrue and unjust. An emphasis on the interaction of many different minds and the contribution of many ideas would come closer to the truth and to the real excitement of modern science.

Inspiration for a hydrogen bomb came from the sun and the stars. A native son of Russia, George Gamow, initiated the theoretical work in the United States that ultimately led to the biggest man-made explosion.

weapons work. Fermi, Bethe, and dozens of others left Los Alamos. Even Oppenheimer, who had supported and urged the thermonuclear effort for years, turned his back on the project. Publicly he announced: "The physicists have known sin." Privately, on the day of Hiroshima, he came to my Los Alamos office for a long talk. He told me that we would not develop a hydrogen bomb. Before Nagasaki, before the war was over, Oppenheimer made it clear to me that he would have nothing further to do with thermonuclear work.

Some members of the small wartime group that had worked on the thermonuclear project at Los Alamos resisted the great exodus of physicists from the laboratory and remained to prepare a summary review of the possibilities of the hydrogen bomb. Stanley Frankel and Nicholas Metropolis worked hardest and longest on this report. They considered the findings we had made in Berkeley in 1942 along with all other relevant data: early measurements made by John Manley, Elisabeth Graves, Marshall Holloway, and Charles Baker; contributions from Fermi and John von Neumann; and the important work of Konopinski who, with Cloyd Marvin, Jr., proved that a thermonuclear reaction—even if initiated on the earth—could under no circumstances spread to ignite the atmosphere or the oceans. The report by Frankel and Metropolis delivered a verdict on the feasibility of a thermonuclear bomb: Difficult, but with hard work and concentrated effort, hopeful.

Neither the hard work nor the concentrated effort was in sight. There was no backing for the thermonuclear work. No one was interested in developing a thermonuclear bomb. No one cared. Even keeping Los Alamos alive was an uphill fight, a crucial battle won by the new director of the laboratory, Norris Bradbury. With the existence of the laboratory itself endangered, all-out support for the development of a weapon as devastating as a thermonuclear bomb could hardly be expected. The exceedingly small group of experts whose thermonuclear skills had been developed during the war disbanded. I, too, left Los Alamos, and

not a single member of the wartime thermonuclear group continued to devote his full time and energy to advanced weapons. But the idea of a Super bomb did not die. A very small Los Alamos group headed by Robert Richtmyer kept the spark alive. From my base at the University of Chicago, I traveled to Los Alamos frequently during the years after Hiroshima to confer with Richtmyer's group. From the beginning, our thermonuclear work assumed a new direction and acquired a new style.

I am convinced that if, after Hiroshima, men of Oppenheimer's stature had lent their moral support—not their active participation, but only their moral support—to the thermonuclear effort, the United States would have shaved four years from the time it took this country to develop a Super bomb. But the thermonuclear work was given almost no support in the last months of 1945—or in 1946, 1947, or 1948. Many physicists and government officials were convinced that in the atomic bomb America had the weapon ideally suited for our policy of massive retaliation. The people were comforted by published pronouncements that Soviet Russia could not attain an atomic explosion for at least twenty years. Some leaders felt that work on advanced weapons would make the United States appear to be a warmongering nation bent upon a world arms race. Then, in the fall of 1949, Russia's first atomic explosion made us realize that an arms race was no longer a possibility to be avoided but a frightening reality to be faced.

At Los Alamos, the feeling was widespread that this was the time to pursue development of the hydrogen bomb. A few months before the Russian explosion, I had returned to Los Alamos on a year's leave of absence from the University of Chicago. I felt that the Russians would follow their development of a fission bomb with a success in fusion. In that case, the Soviet Union would be far ahead of the United States in the field of nuclear weapons. When Los Alamos was established in 1943, it was understood that

thermonuclear possibilities were to be thoroughly explored. After Russia's first atomic explosion, most of us at Los Alamos felt that the time finally had arrived.

Our enthusiasm was not shared by the powerful General Advisory Committee of the Atomic Energy Commission, headed by Oppenheimer. This committee often had a determining voice in AEC policies. On October 29, 1949, a month after President Truman's announcement that Russia had achieved an atomic explosion, the General Advisory Committee met in Washington to give the AEC an opinion on the advisability of undertaking development of a thermonuclear bomb. Committee members, after a round-table discussion of the problem, voted unanimously against any H-bomb program. The unanimous report included this statement: "We all hope that by one means or another, the development of these weapons can be avoided. We are all reluctant to see the United States take the initiative in precipitating this development. We are all agreed that it would be wrong at the present moment to commit ourselves to an all-out effort towards its development."

The GAC report carried two supplementary statements that became known as the majority and minority reports, although the controlling recommendation was unanimous. The majority report was signed by Oppenheimer, James B. Conant, Lee DuBridge, Hartley Rowe, Cyril Smith and Oliver E. Buckley. In its final paragraph, the majority report said: "In determining not to proceed to develop the Super bomb, we see a unique opportunity of providing by example some limitations on the totality of war and thus eliminating the fear and arousing the hopes of mankind." The minority report, signed by Fermi and I. I. Rabi, held: "The fact that no limits exist to the destructiveness of this weapon makes its very existence and the knowledge of its construction a danger to humanity as a whole. It is necessarily an evil thing considered in any light. For these reasons, we believe it important for the President of the United States to tell the American public and the world that we think it is wrong on fundamental

ethical principles to initiate the development of such a weapon."

The negative recommendation of the General Advisory Committee was not communicated immediately to Los Alamos. An effort was made to keep congressional leaders from knowing that scientists close to the problem might disagree with the GAC report.

A few days after the GAC meeting, I was on my way from Los Alamos to Washington to keep an appointment with Senator Brien McMahon, chairman of the Joint Congressional Committee for Atomic Energy. I stopped to see Fermi in Chicago. Despite our very close personal relationship and his knowledge of my almost desperate interest in the thermonuclear effort, he insisted that he could not even give me an indication of the GAC decision. But it was clear from the tenor of his remarks that certainly Fermi and possibly the entire GAC did not favor an all-out crash program. While I was in Fermi's office, I received a telephone call from John Manley, secretary of the General Advisory Committee who also was associate director of Los Alamos. Manley asked me not to see Senator McMahon. I asked why I should not. He replied that it would be unfortunate if congressional leaders thought that scientists had a divided opinion on the thermonuclear question. I told Manley that I had an appointment with Senator McMahon and intended to see him. Manley insisted that I should not. I offered to telephone Senator McMahon and tell him that I was canceling my trip to Washington because I had been asked not to see him. Then Manley gave up, saying: "All right. You better go and see him."

I still did not know the contents of the GAC report when I saw Senator McMahon, and he did not reveal them to me. He did, however, use strong words in reference to the report even before I had an opportunity to ask about it. He said: "I read this report, and it just makes me sick." Still a little mystified about the actual recommendation of the GAC, I told Senator McMahon that I considered it vital to the nation's defense that we proceed with the thermonuclear work. He assured me that he would do

everything in his power to make the thermonuclear bomb a reality.

Almost two weeks passed before I had certain knowledge of the GAC recommendation. Manley, back in Los Alamos, asked me into his office and showed me both the minority and majority reports. I could see little difference between them, and I was certain that the thermonuclear effort had been effectively killed.

I was, however, completely mistaken. The report produced precisely the opposite effect among the Los Alamos scientists. Immediately, of course, the GAC report did stop work on the thermonuclear bomb, because it was tantamount to an explicit instruction to that effect. After a few days, however, the implications of the report began to sink in. It seemed to restrict the Los Alamos scientists to minor improvements in the old field of fission. But many of the scientists, especially the younger men, found it difficult to control an adventurous spirit urging them to get into the newer field of thermonuclear reactions. The GAC report seemed to state the conflict rather bluntly: As long as you people work very hard and diligently to make a better atomic bomb, you are doing a fine job; but if you succeed in making real progress toward another kind of nuclear explosion, you are doing something immoral. To this, the scientists reacted psychologically. They got mad. And their attention was turned toward the thermonuclear bomb, not away from it.

This psychological reaction to the GAC report, this scientific anger, certainly could not have produced a hydrogen bomb by itself alone. Solution of the theoretical and engineering problems involved in the thermonuclear program required an intensive effort, a concerted action impossible to achieve in a laboratory instructed not to work on the problem. Without a clear go-ahead, Los Alamos could not have produced a hydrogen bomb. Empty anger was not enough. A decision was needed. And President Truman was urged to make that decision by AEC Commissioner Strauss, Senator McMahon, and other members of the Joint Congressional Committee for Atomic Energy.

Ironically the man who gave our atomic secrets to Russia also had an important influence on the decision to proceed with the hydrogen bomb. Klaus Fuchs, who was at Los Alamos when we reviewed all we knew about thermonuclear reactions after Hiroshima, confessed in late January 1950 that he had passed secrets to Communist agents. Four days after Fuchs' confession, President Truman overrode the recommendation of the GAC and directed the Atomic Energy Commission to go ahead with the hydrogen bomb.

The presidential directive was not a complete surprise to me. A few days before President Truman's decision was announced, I met Oppenheimer at a conference on atomic energy. He made it clear that a top-level decision was being made, and that it probably would direct development of a hydrogen bomb. Recalling his effective leadership of the laboratory during the war, I asked Oppenheimer whether he would really go to work on the hydrogen bomb if President Truman did authorize an all-out thermonuclear program. His reply was negative.

Although I was prepared for the presidential decision of January 29, 1950, I was not prepared for the language of the decision. President Truman directed the AEC to *continue* its thermonuclear program, giving the impression that we could produce a hydrogen bomb simply by tightening a few last screws. People understood from his announcement that the job was almost done. Actually, work had not begun. We had eight years of thermonuclear fantasies, theories, and calculations behind us; but we had established no connection between theory and reality. We needed a thermonuclear test.

I still was associated with the Los Alamos Scientific Laboratory when President Truman announced his decision. But, distressed by the opposition of the GAC, I had accepted an appointment as professor of physics at the University of California in Los Angeles and planned to begin teaching in the fall of 1950.

During March and April of 1951, I urged the feasibility of constructing a hydrogen bomb upon anyone who would listen. Early in March, I discussed the report in detail with Norris Bradbury, the director of the Los Alamos Laboratory, Mark, head of our theoretical division, and others at the laboratory. In April, I explained my ideas to Gordon Dean, chairman of the Atomic Energy Commission. Dean seemed interested, but somehow distracted. After leaving his office, I discovered the reason for the distraction: The zipper on my trousers had failed, and my fly was open. Dean remembered my open fly, but not my ideas. Two months later, during another presentation, he seemed to be hearing the ideas for the first time. But in the meantime he had told a magazine reporter that I was a "brilliant if somewhat disarrayed scientist."

Our proof that a practical hydrogen bomb could be economically constructed was based, of course, on theoretical calculations that had not been verified experimentally. That verification, the basic proof needed before making a real H-bomb, came with Greenhouse. Few scientific experiments have been conducted under conditions as exotic or in a place as beautiful as the Pacific setting for the first thermonuclear explosion. Rising early that May morning, we walked through the tropical heat to the beach of Eniwetok's placid lagoon. Again, we put on dark glasses. Again, we saw the brilliance of another nuclear explosion. Again, we felt the heat of the blast on our faces. But still, we did not know whether the experiment had been a success. We did not know whether the heavy hydrogen had been ignited. We did not know whether we had merely seen the explosion of the triggering atomic bomb or actually had witnessed the world's first thermonuclear explosion. The mushroom cloud we saw rising beyond the lagoon showed only that we had been successful in asking a question. The answer had to come from the reports of the recording instruments.

Time was required to gather and interpret those reports, and the twenty-four hours following the test were filled with anxiety.

That afternoon, to break the tension, Ernest Lawrence invited me to swim with him in the lagoon. When I came out of the water to stand on the white sands of the beach, I told Lawrence that I thought the experiment had been a failure. He thought otherwise, and bet me five dollars that we had been successful in igniting heavy hydrogen and producing a thermonuclear reaction.

I was hardly awake the next morning when Louis Rosen burst into my quarters to announce: "I have the evidence! Only one piece, but I have evidence that the test was a success. Please, please tell no one until it is verified." I promised. But Lawrence was leaving the island that morning before additional readings could be made. I kept my promise to Rosen. I told no one, and I waited as long as I could for final verification. But when Lawrence left for the air strip, I could wait no longer. I ran after his jeep and silently handed him five dollars. It was worth it. I knew that success at Greenhouse ensured the successful construction of a hydrogen bomb along the lines detailed in the report to which De Hoffmann had signed my name two months earlier.

A month after Greenhouse, the Atomic Energy Commission called a significant round-table conference to determine the best way to build a hydrogen bomb. The meeting was held June 19 and 20 at the Institute for Advanced Study at Princeton. Oppenheimer, as chairman of the Weapons Committee of the GAC, presided. Members of both the AEC and the GAC attended, along with Los Alamos scientists.

I was amazed when Carson Mark, in his presentation, did not mention the hydrogen bomb report that I had handed him three months before. My amazement multiplied when Gordon Dean, still chairman of the AEC, spoke without mentioning the same report, which I had explained to him two months earlier. My amazement approached anger as other scientists and officials who

knew of the report spoke without referring to it. Finally, I could contain myself no longer. I insisted on being heard. My demand was met by a spirited debate, but it was decided that I should be allowed to speak. I walked to the blackboard and again went through the theory and calculations that already were familiar to half the men in the room.

Response to the theory, now supported by the experimental evidence of Greenhouse, was enthusiastic and unanimous. Gordon Dean, who apparently had found my sloppy dress an insurmountable distraction two months before, later testified: "Out of the meeting came something which Edward Teller brought into the meeting within his own head, which was an entirely new way of approaching a nuclear weapon. I would like to be able to describe that but it is one of the most sensitive things we have left in the atomic energy program. . . . At the end of those two days we were all convinced, everyone in the room, that at least we had something for the first time that looked feasible in the way of an idea. . . . I remember leaving that meeting impressed with this fact, that everyone around that table without exception, and this included Dr. Oppenheimer, was enthusiastic. . . ."

During the months preceding and following the Princeton meeting, ingenious and reliable calculations were carried out in connection with this new kind of nuclear explosion. Marshall Rosenbluth, Conrad Longmire, Lothar Nordheim, and many others made accurate predictions about details of the way our new device would function.

Under the leadership of Marshall Holloway, a new test was prepared on one of the islets of the Eniwetok chain, Elugelab. On November 1, 1952, this islet was wiped off the face of the earth by the first full-scale thermonuclear explosion.

I was not on hand for the explosion of the first hydrogen bomb. I left Los Alamos exactly one year before that momentous event. The battle for the thermonuclear bomb had been won at the Princeton conference, and I was drawn to the fight for establish-

About fifteen minutes were required for the shock of the explosion to travel, deep under the Pacific Basin, to the California coast.

I waited impatiently, and watched the seismograph make a time signal each minute. At last the time signal came that had to be followed by the explosion's shock, and there it seemed to be: The spot of light danced wildly and irregularly.

But I almost convinced myself that what I had seen was the motion of my own hand and the pencil it was holding rather than the signal from the first hydrogen bomb. The film was taken from the seismograph and developed, and the tracing appeared on the photographic plate. It was clear and big and unmistakable. It had been made by a wave of compression traveling thousands of miles and bringing positive assurance that our first hydrogen bomb had been a success.

I believe that everyone who worked on the hydrogen bomb was appalled by its success and by its possible consequences. I also believe that everyone who was closely or distantly connected with the effort—along with those who have made subsequent contributions—was driven by the knowledge that the work was necessary for the safety of our country.

We would be unfaithful to the tradition of Western civilization if we shied away from exploring what man can accomplish, if we failed to increase man's control over nature. The duty of scientists, specifically, is to explore and to explain. This duty led to the invention of the principles that made the hydrogen bomb a practical reality. In the whole development I claim credit in one respect only: I believed and continued to believe in the possibility and the necessity of developing the thermonuclear bomb. My scientific duty demanded exploration of that possibility.

Beyond the scientific responsibility to search the horizons of human knowledge, the responsibilities of scientists cannot be any greater than those of any other citizen in our democratic society.

The theoretical supervision of all our projects became Mills' responsibility. Taking his cue from the sad post-mortem sessions that had followed our early failures, Mills launched the exceedingly useful pre-mortem discussions that preceded our later successes. Before any new device was tested, it was reviewed and discussed by some of our experienced scientists who had nothing to do with its development. Mills' pre-mortem discussions of each new device provided valuable independent criticism while welding the laboratory into a single, purposeful unit. The pre-mortem sessions helped us to avoid becoming a collection of specialists who had only a nodding acquaintance with each other's difficulties and accomplishments.

Even while the Livermore Laboratory was making rapid and valuable progress in weapons development, Ernest Lawrence was participating in a serious and determined attempt to ease cold-war tensions by finding a way toward effective and verifiable disarmament. Harold Stassen, leader of the Eisenhower administration's disarmament effort, organized an advisory group of experts. As a member of this group, Lawrence was responsible for all aspects of disarmament connected with nuclear energy. He asked several of us at Livermore to help him in this work. Foremost in our group was Mark Mills.

These disarmament efforts, like all others, eventually were blocked by the stone wall of Communist intransigence. But during the discussions we did make a simple and practical proposal: Nuclear arms are small, powerful, relatively inexpensive, and easily hidden. Disarmament, therefore, should not begin with nuclear disarmament. The first steps toward disarmament, instead, should be taken in fields where the cost of weapons is higher and where armament is more conspicuous and more easily checked. Only after international tensions are relaxed and mutual confidence established by measures of conventional disarmament

should we tackle the infinitely more difficult task of nuclear disarmament.

In the meantime, we thought an important concession could be made to public opinion. The dangers of radioactive fallout in the atmosphere had been exaggerated out of all proportion. Millions of people were worried about fallout. Although the danger was purely imaginary, the worries were real. We proposed that the amount of radioactivity released into the atmosphere should be limited to a small amount that could be proved harmless in a completely convincing way. This simple and moderate proposal, unfortunately, was neither pressed upon the Administration nor explained to the public.

As the fear of fallout mounted, the clamor increased in this country for a halt of all nuclear tests. The emotional appeal of such a radical demand was all too clear: The root of all the fears, troubles, and anxieties of the atomic age was the atomic bomb. Stop development of such monstrous weapons, and all the world's difficulties will vanish. Let us set the clock back beyond Hiroshima. Or, if we can't do that, let us at least stop the clock now.

Clocks can be turned back or stopped, but time cannot. I felt that we could not stop progress, that advances certainly would be made in the nuclear field by Russia if not by the United States.

Early in the summer of 1957, Lewis Strauss took Ernest Lawrence, Mark Mills, and me to see President Eisenhower. We described to the President some of the probable future developments in the field of nuclear explosives. One point was raised in the discussion which was and still is of great importance: We can perfect "clean" nuclear explosives. These can be used in war to destroy an intended target without releasing radioactivity to be carried by the winds to do damage indiscriminately where no damage was intended. These "clean" explosives can also be used in peace as a powerful workhorse in mammoth construction jobs.

President Eisenhower listened to our arguments. And, for the time being, we obtained permission to proceed with our work.

Within months I became deeply worried about the future of the Livermore Laboratory. In the fall of 1957, Russia's Sputnik flashed through the skies, and the people of the United States suddenly were engrossed in the space age.

The time of Sputnik was the time for us to redouble our efforts to ensure the safety of the free world. But we did little. We did increase our work in rocketry and we did, at last, establish a sizable space program of our own. Some defense funds, cut in an "economy" move, were restored to the budget. But in the development of nuclear weapons, there were signs of a coming slowdown.

That the nation should do more about exploring space for our peace and security was necessary. With the Soviet Union the first into space, establishment of an effective United States space program was mandatory. But to neglect the fast-growing field of atomic energy and particularly to neglect development of nuclear explosives seemed to me to be ill-considered and dangerous.

Still, the national neglect of nuclear programs that followed Sputnik could be understood. We faced a new challenge in space, and the challenge captured the public imagination. To think of man soaring to the moon was something new and exciting. To think of nuclear explosives suddenly was old hat. People were fascinated by the glamour of space. Nuclear explosives seemed unfashionable and repulsive.

Herbert York, whose work as director of the Livermore Laboratory had been excellent, went to Washington to devote himself to his original ambition: Space exploration. Before long, he was named Assistant Secretary of Defense for Research and Development. I asked Ernest Lawrence, as over-all director of the University of California's Radiation Laboratory, to give me the responsibility for the Livermore branch. A few months earlier, I had expected to work only on purely technical projects. But under Lawrence's direction I felt that I could make an important administrative contribution at Livermore during the dangerous

period when public interest in nuclear projects and support for our work were waning.

Lawrence promised me his full support, and so I began an unusual, difficult, and important job. I hoped to work as director of the Livermore Laboratory for only one year, a year that I felt would be crucial in the continuing development of our nation's defense. Then I expected that Mark Mills would assume direction of the laboratory, allowing me to return to science. But this was not to be.

Mills, in April of 1958, was working in the Pacific Proving Grounds. A new series of tests was approaching, and Mills was involved in some important preparations. On the evening of April 7, he found it necessary to move from one island to another in the Eniwetok chain, and he requested a helicopter. The weather was threatening, but no one was aware of a real danger. The helicopter was considered safe.

A young physicist, Dr. Harry Keller, and an Air Force medical officer, Col. Ernest A. Pinson, flew with Mills in the helicopter's cabin. Two pilots occupied the cockpit. Flying low near the edge of the lagoon, the helicopter was caught in a squall. It crashed into eight feet of water.

The two pilots got out safely. The passengers were trapped in the cabin.

Colonel Pinson was able to float and breathe from the air bubble that formed above the water in the cabin. Then he kicked out a cabin window, escaped and joined the pilots. Right after this harrowing experience, he returned with the pilots to rescue his friends from the cabin.

They found Harry Keller unconscious. They dragged him from the cabin and in the darkness, on top of the helicopter, started artificial respiration. Keller escaped with a case of pneumonia, and after several weeks he recovered.

Colonel Pinson and the two pilots searched in vain for Mark

Mills. Hours later, when the rescue team arrived, he was found, still strapped in his seat, dead.

Mark Mills' death was a dreadful blow. On the following day I assumed the directorship of the Livermore Laboratory. I felt lonely and lost. I had thought that Mills and I would undertake the job jointly, and that within a short time he would assume the full responsibility.

But Mark Mills even in death was a potent influence for a unified effort, friendly spirit, and good humor in the Livermore Laboratory. Mills was gifted with a very pleasant and even temper. After his death, the scientists of Livermore seemed to enter a silent conspiracy: The right way to keep the memory of Mark Mills among us was to imitate him.

It became increasingly clear that the tests of 1958 would be the last—at least for a long time. The Soviet Union stepped up its propaganda for a cessation of nuclear tests. The Eisenhower administration seemed to become more and more interested in nuclear disarmament. Herbert York told me, quite explicitly, that the test series of 1958 would be our final chance to make experimental progress. I was deeply grateful to him for this warning. At the same time, it was one of my greatest disappointments to find that he did not help us in our fight for continued development of nuclear explosives. This was a great change from his earlier words and actions. I never was able to understand his reasons.

The Livermore Laboratory made a superb effort to realize the most from this last opportunity for experimental advances. During the hectic months before a test cessation finally became effective that fall, we had many surprises. Some were disappointments. Some were successes surpassing our most optimistic expectations. We had to make last-minute adjustments. We sometimes had to act on guesses.

The planners of our nuclear devices—John Foster, Carl Hauss-

mann, and others—pressed to include as many experiments as possible in the 1958 series. The laboratory's deputy director, Kenneth Street, worked feverishly with Duane Sewell, who represented common sense in our midst, to schedule everything possible and then just a little more on the test program. And finally it was Gerald Johnson's job, first in the Pacific and later in Nevada, to convert these test plans into realities.

When it was all over, when the series of experiments was finished, when the test moratorium became effective on the last day of October, there was no one in the Livermore Laboratory who could have continued the killing pace. Many on the staff had been working twelve hours a day, steadily, for weeks. Families had been separated for months. But the operation was completed without mishap, and the total results added up to the proper continuation of the increasingly successful program of Livermore.

The efforts of the people at Livermore during the critical summer and fall of 1958 were incredible. The result of their dedicated labor is that our nation today is stronger, and we have a little more time in which to prepare for a difficult future.

While the pitch of activity rose in Livermore during the summer of 1958, an international Conference of Experts convened in Geneva to consider the technical feasibility of policing a test moratorium. Ernest Lawrence was asked to participate. His health was not good, and he knew that the exertion and excitement of Geneva could be dangerous. But he accepted the difficult assignment without hesitation. Lawrence took Harold Brown with him to Geneva. We missed Brown at Livermore during this decisive period, but the need for his quick and thorough understanding was even greater at Geneva.

After participating in the Geneva talks for only two weeks, Lawrence became seriously ill. He tried to stay, but his health did not improve. He came home in a dangerous condition.

I was most anxious to see him, but it was important that he should not be disturbed. At last I was permitted a brief visit, but I was warned that all serious conversation was to be avoided. Lawrence was cheerful when I saw him in the Palo Alto hospital, and it was almost easy to follow the doctors' orders and talk with him pleasantly about pleasant subjects. But at one point he changed his tone. It was clear that he wanted to say something important.

Defying his physicians' explicit orders, Lawrence spoke to me briefly about business. He talked about Harold Brown. The work Brown had done in Geneva, he said, had been splendid. Brown had been able to respond with whatever attitude was demanded by the difficult talks. Displaying a magnificently shrewd sense of diplomacy, he had at various times been moderate, sharp, or determined. He had been the best defender of our cause. Lawrence knew that I was looking for someone to succeed me as director of the Livermore Laboratory. He urged me to stay on the job as long as I could. But he also told me that when I did want someone else to assume the responsibility, I could find no one better than Harold Brown.

A few weeks after this discussion, Lawrence was dead. He had used himself beyond endurance. He had opened a broad field of science, had built a splendid laboratory, and had helped others so they could carry on his work. And he had sacrificed his life for science and for his country.

I spent more than two years as director of the Livermore Laboratory. They were the busiest years of my life. In many respects they were the most satisfying, and the satisfaction came from the human success and the human growth of the young people around me.

The laboratory itself grew. The staff came to number nearly four thousand, and the spheres of scientific interest broadened. In addition to development of nuclear weapons, large sections of

the laboratory became engaged in attempts to control thermonuclear reactions, in work on nuclear rockets, in plans for peaceful applications of nuclear energy, and other projects.

But although the Livermore Laboratory became large, it did not become unwieldy. Its organization remained close-knit, and this was largely to the credit of Kenneth Street, a deeply conscientious man of enormous vitality who was a fighter pilot during the war, a professor of chemistry after the war, and later deputy director of the Livermore Laboratory. He longed to return to his students and to his research. But he first wanted to see the organization of the Livermore Laboratory on a solid foundation. At Street's suggestion, we placed the laboratory under the responsibility of a half-dozen associate directors. Each had charge of certain areas of activity. The associate directors met weekly to make over-all decisions jointly. This prevented the laboratory's administration from becoming cumbersome, and at the same time maintained Livermore as a living, unified organization—much more than a sum of its parts.

Fears that establishment of a second weapons laboratory would demoralize the scientists of Los Alamos and perhaps actually slow our nuclear progress never did materialize.

The first hydrogen bomb was developed and perfected at Los Alamos. It was tested successfully just as the new Livermore Laboratory was being organized. And within three years of the founding of the weapons laboratory at Livermore, the young physicists gathered in California began making substantial and important contributions toward the development of lightweight nuclear weapons.

The laboratories at both Los Alamos and Livermore are today operated by the University of California under contracts with the Atomic Energy Commission. While the two laboratories constantly aid each other by pooling information, the men of each laboratory are prodded and goaded into doing their very best

work by a spirit of friendly competition. It is a competition for ideas, not for glory. It makes no real difference which of the two laboratories is credited with great accomplishments. The only important thing is that each laboratory does the very best that it can—and that together they do what is enough.

With two great laboratories engaged in a competition for ideas to keep the United States strong, I became more and more certain that the time had come when I could relinquish my post at Livermore. The very excellence of my associates at the Livermore Laboratory convinced me that my work as director was not essential. For decades I had considered myself primarily as a scientist and as a teacher—not as an administrator. I decided, almost twenty years after becoming an American citizen, that I could best serve my country by returning to the classroom and the laboratory.

But there was another more urgent and more compelling reason for the decision to leave my job. As director of the Livermore Laboratory, I had to be most careful in making any public statement. And if one is too careful, one cannot really be convincing.

Care was essential. As director of a weapons laboratory operated for the Atomic Energy Commission, my personal and private views and recommendations on our nation's course in the nuclear age could be interpreted as reflections of official AEC policy. John McCone, chairman of the AEC, treated me as a real friend and gave me every possible latitude to express my own ideas publicly. But the very fact of his friendship increased my responsibilities and my caution.

The drift toward appeasement, toward making some accommodation with the Soviet Union, on the part of both the American people and American officials made me more uneasy with each passing month. In 1949 and 1950 a group of influential scientists argued against the development of the hydrogen bomb. They said—at various times—that the effort was immoral, that

further progress was impossible, and that if we stopped in our dangerous course the Russians would do likewise. Now, a decade later, many of the same scientists argued against further work on nuclear weapons. Their arguments were the same: The work is immoral, it is useless, and in any case the Russians will cooperate. In 1949 these arguments did not prevail. Ten years later they seemed to find general acceptance. But as long as I was director of the Livermore Laboratory, I felt that I could not speak out in a strong voice.

Because I had been involved in a number of significant developments and discussions, I had an opportunity to be heard in a debate likely to determine the future of the United States. This opportunity appeared to me as a duty. There were many things I wanted to say, things that I was convinced needed saying, that could be said effectively only if I were free of any official restraints. They could be said only if I divorced myself from government work.

So on July 1, 1960, I resigned as director of the Livermore Laboratory and asked Harold Brown to take that post. My immediate purpose was to write the book you hold in your hand.

Most people responded to such ideas with a shrug and with an incredulous smile. But, after a short time, many of us at the Livermore Laboratory were convinced that nuclear explosions could be thoroughly useful.

During the same summer, Brown mentioned the idea to Dr. I. I. Rabi, a famous physicist with a quick wit. Rabi responded to Brown's enthusiasm with a dry remark: "So you want to beat your old atomic bombs into plowshares."

Brown had no reply, but he now had a name for his special interest: Project Plowshare.

Fortunately, there was an early opportunity to get started with Plowshare. David Griggs, who had effectively aided establishment of a second weapons laboratory, suggested in 1956 that we explore the effects of an explosion deep underground. Griggs, by profession, was concerned with the physics of the earth, and thought that an underground explosion might produce information about the processes occurring in the earth's crust. He pointed out that all the radioactivity produced by an underground explosion would be imprisoned. Necessary safety measures could be simplified, and we no longer would need to mobilize an army of meteorologists to predict wind directions for a test. We could gain flexibility by preparing appropriate locations for underground testing, and we then could proceed with a nuclear experiment whenever we were ready.

Gerald Johnson, who was in charge of Livermore's nuclear tests, recognized these advantages. He also realized that an underground experiment could have an important bearing on our plans for Project Plowshare. The experiment was scheduled for September 1957.

An explosive equivalent to 1700 tons of TNT was placed in a mesa in the Nevada desert. From an observation post a few miles away, a small group from Livermore watched the explosion. They saw much less than they would have seen in an atmospheric test.

The mesa shivered and appeared to lighten in color. The top

of it jumped upward nine inches, throwing up some sand that cascaded down the slopes. Then the earth fell back into place, apparently unchanged except for a few fissures. A slight shock was felt at the observation post. No trace of radioactivity escaped. The experiment was complete.

Then the real work started. The Livermore team had to discover what had happened inside the mountain. The radioactive deposit had to be found. It took weeks to locate the radioactivity, months to piece together details of the underground drama.

The explosion, 797 feet from the mesa's nearest surface and 900 feet from its top, vaporized rock to blow a hole 110 feet in diameter. This hole was lined with four inches of molten rock which contained much of the radioactivity produced by the explosion. Icicles of rock formed in this molten layer and dripped. Then the entire cavity collapsed. Forming a cup beneath the point of explosion, the molten layer congealed into a glassy substance imprisoning much of the radioactivity in an all but insoluble form.

The porous, water-saturated rock around the original hollow sphere was crushed and lost much of its water. When the hollow sphere collapsed, a chimney of rubble 400 feet high and weighing more than 100,000 tons was formed above it. Unlike nearby material, the rubble in this chimney was water-permeable. Some radioactivity had escaped into it. All this radioactivity was watched for years. It moved inches, feet. Long before it could reach any living thing, it would decay. After more than a year the loose material in the chimney again solidified, and it no longer was permeable to water.

All this was highly interesting, and it was most important to Project Plowshare. Our experiment had confirmed that we could break up large quantities of rock and make it permeable to water. And other nuclear explosions had taught us that we could greatly reduce the total radioactive output of a bomb. In time, we could make our Plowshare tools "clean."

Many of Plowshare's potentialities are thoroughly understood today. Others are only dreams for the future. The most important and effective applications may have occurred to no one.

If anyone wants a hole in the ground, nuclear explosives can make big holes. We know how to make holes of a thousand-yard diameter for a small fraction of the cost of traditional excavation methods. The ability of nuclear explosions to move vast quantities of earth and rock—and to move them cheaply—opens a new and important discipline: Geographical engineering. We will change the earth's surface to suit us. We can place appropriate nuclear explosives in such a way that craters resulting from their detonation will overlap, creating man-made harbors, digging deep and rather smooth canals for seagoing vessels, opening shallow and rock-filled rivers to navigation. The cost of moving a cubic yard of material today is one or two dollars. Plowshare can do it for a few cents.

The world needs more harbors and canals. There is much too little protection for big ocean-going vessels along the western shores of South America and Africa. More water transportation, because it is the cheapest form of transportation, would speed the development of backward countries, would increase trade, and would strengthen ties between peoples. But Plowshare should be demonstrated at home before it is exported to others.

Where can the United States make a beginning? Where large populations have settled, we do not want to dig harbors and canals with nuclear explosions. In areas where there are few people, there is no immediate need for harbors or canals. So Plowshare planners have selected as possible sites for artificial harbors areas that are not yet heavily populated but where we expect great developments in the future. There are many areas in which rich ore deposits remain untouched because there is no nearby harbor for economical transportation of the resources.

Such a site has been found in Alaska, where coal deposits near the Pacific coast and our Navy's valuable oil reserves on the inland Arctic slope south of Point Barrow remain virtually un-

reachable. Ogoturuk, Alaska, south of Point Hope on the Arctic Ocean, is being given careful consideration as the site of our first Plowshare harbor. The harbor basin and the canal connecting it to the ocean would cost less than 10 million dollars. Only four nuclear explosions, each with a yield of 20 kilotons, would be needed to dig a deep-water canal with a width of 250 to 300 yards. A turn-around harbor basin 600 yards in diameter could be dug at the end of the canal with a 200-kiloton nuclear explosion. It would not be difficult to use somewhat bigger yields and create a harbor-canal structure of really respectable dimensions.

We ship coal from Pennsylvania to Japan today through the Panama Canal, and such shipments are made at considerable expense. Appropriate harbors in Alaska would be an economic boon to our forty-ninth State and would benefit the Japanese people by giving them cheaper fuel. It would be wonderful if the nation that has been exposed to the destructive power of atomic explosions would be the first to benefit from the peaceful uses of the same instrument.

Radioactive fallout resulting from such a peaceful series of explosions would be negligible. The huge holes needed for harbors and canals would be created with nuclear devices buried rather deep underground. They would raise vast quantities of earth and rock into the air to be blown away from the site by the wind, and they would push some dirt outward to form the lips of the canal and harbor. But most of the explosion's radioactivity would be trapped deep underground. No more than fifteen per cent could escape as gaseous radioactivity. Some of this could turn into dangerous Strontium 90, but if we are careful in the selection of sites for Plowshare explosions and if we take the necessary precautions, we can be sure that no person will be exposed to radiation effects greater than everyone receives from natural sources.

Furthermore, we have had some success in the development of "clean" nuclear explosives that create little or no radioactive

Sputnik caused fear. It was painfully apparent that Russia, capable of throwing a satellite around the earth, also could launch a device armed with an atomic bomb or a hydrogen bomb. Watching Sputnik flash overhead in the night, Americans realized as never before that our nation was in the range of Russian rockets—rockets that could carry the terrible destructiveness of nuclear weapons from launching pad to target, from continent to continent, from hemisphere to hemisphere in twenty minutes.

Sputnik shrank the world and canceled the guarantee of safe isolation that had been provided us by the great oceans. Sputnik made it obvious and essential that we revise our preparations for national security, overhaul our plans for civilian defense, abandon concepts that suddenly were obsolete, and concentrate on a new kind of technological exploration.

In the range of Russian rockets, we could not hope to evacuate our cities and prime target areas in case of attack. Our fighter planes, designed to meet approaching bombers, could not be used to protect us against missiles. Wartime attack by long marches of weary men had been a matter of months. Bombing tactics perfected during World War II made conflict a matter of hours. Sputnik made destruction a matter of minutes.

The Russian achievement was a surprise. Actually, it should have been expected. Long before Sputnik, we had persistent reports and published evidence of a great Soviet effort in space technology. In Geneva during the 1955 Conference on the Peaceful Uses of Atomic Energy, our scientists were impressed by Russian interest and achievements in space projects. Our military experts were aware that Russian rocketry had played a great part in repulsing German forces at Stalingrad, and we were equally aware that after World War II some of the most accomplished German rocket technicians and space scientists had disappeared behind the Iron Curtain.

Russia had good reason to be interested in rocket development,

and good reason to be content with the step-by-step progress from short-range to long-range rocketry. Concerned about the behavior of nations near her borders, Russia had a potential use for short-range rockets.

The United States, on the other hand, was only mildly interested in rocket development after World War II. Our military strategists believed that rockets would be useful to the United States only if they could span the oceans and hit a target with an accuracy that would destroy that target. We did not believe that this high degree of accuracy would be possible, considering the probability of error posed by thousands of miles of delivery. While Russia was pushing rocket development, our military leaders felt that delivery of a long-range rocket would be so inaccurate that even with an atomic bomb as a pay load, a long-range rocket would not destroy an intended target. So, instead of developing rockets as carriers for atomic weapons, the United States concentrated on refinements of bombers.

This was a grave error of judgment. No single political administration can be blamed for it. It was a military decision that neglected the rule that a person must learn to walk before he can run. The Wright Brothers had to fly their clumsy airplane a few hundred feet at Kitty Hawk before we could develop modern jet planes. The atomic bomb had to be developed and tested before we could construct a practical thermonuclear bomb. The short-range rocket should not have been given a low priority by our military experts, but should have been recognized as a forerunner of the intercontinental ballistics missile and of the vehicles that were to reach out into space. Our experts' erroneous judgment gave Russia a head start in rocketry. It opened the missile gap.

This dangerous error involves a bitter lesson that we have not yet learned. Military planners in the United States depend too much on their crystal balls. They attempt to look into the scientific future, and try to make precise predictions of military requirements for many years to come. They try to order keys for

specific locks they have not even seen. They try to guess what weapons our potential enemies might develop in the decades ahead, and then formulate plans of defense against those weapons. But the future always is uncertain and unpredictable. We know, from the past, that the course of progress can be accelerated or diverted by a single unexpected idea. The weapons which our military strategists think a potential enemy will develop years from now might, indeed, be developed much sooner —or not at all. A Russian scientist's inspiration might provide a break-through to speedy progress, or it might set the development of Russian weapons careening down an entirely new track.

Our best scientific defense against this uncertain future is to make progress where progress can be made. That most marvelous of human instincts, curiosity, if permitted literally to reach for the stars, would pay much higher dividends than any closely motivated, narrow plan. We do have the capacity for mobilizing considerable resources once we have a firmly established purpose. But we often are not doing enough exploratory work. Only after such work can long-range goals be established with real hopes of success. If we had been allowed the free exercise of our scientific curiosity and had been more inspired by an extension of human knowledge—then the United States would be stronger today.

The United States, fortunately, did not altogether neglect rocketry. Despite the judgment of our military strategists that rockets and missiles had little value in our weapons arsenal, the United States immediately after World War II made a start on rocket projects. The program remained modest indeed until we proved the capabilities of the hydrogen bomb. Then such farsighted men as John von Neumann and Trevor Gardner realized that missiles tipped with thermonuclear bombs would be decisive weapons. Military planners who had discounted missiles as carriers for atomic bombs, impressed by the greatly increased de-

structive powers of thermonuclear bombs, reconsidered the practical value of rockets and missiles to our national defense. A step-up was ordered, belatedly, in our missile program. It was not until 1953 and 1954 that rocket development in the United States finally began to gain momentum.

This is the historical reason for Russia's being ahead of the United States in rocketry in 1957, when the first Sputnik was launched. Russia has been ahead of us ever since. Their rockets are bigger and more powerful. They can carry heavier weapons or more equipment. So they can be used in a more flexible manner. And, as far as we can guess, the Russians have more rockets than we. In 1962, the missile gap continues to be a harsh reality.

Even though we have not yet closed the missile gap, even though we have not caught up with Russia in missile performance, even though we should do a great deal more toward building a retaliatory force of poised missiles that cannot be destroyed by an initial enemy attack, our advances have been many and excellent.

We have succeeded in constructing intercontinental missiles that can carry hydrogen bombs. We have produced effective rockets of increasing reliability. We have made a good start toward development of mobile rockets that can be shifted around on land or on sea. In a remarkably short time we have perfected a rocket that can be launched beneath the surface of the ocean. This mobile missile has been named, strangely enough, after the only stationary star in the firmament: Polaris.

Carried aboard nuclear submarines far from prime targets in the United States, the Polaris is an integral part of the kind of retaliatory force upon which the survival of our nation depends. Our nuclear submarines are reliable because they need not surface, have long endurance, and are hard to detect—especially when they are beneath the polar icecap, where they can be at-

tacked only with extreme difficulty. Unfortunately, our nuclear submarines are big, expensive, and few. Today they serve their purpose well. Tomorrow better, faster, and more numerous units will be needed to ensure us against nuclear blackmail.

A retaliatory force is important. A truly effective active defense system would be even more desirable. It would be wonderful if we could shoot down approaching missiles before they could destroy a target in the United States.

An ICBM headed for a target in the United States would move with great speed, much faster than a jet airplane or a bullet. Our reaction time would be necessarily short. The answer to the speed of an ICBM attack is automatic equipment that would locate enemy missiles and release our anti-missile missiles to carry nuclear explosives toward their targets in space. Plans for our missile defense are aided by the circumstance that we would be shooting at a target following a predictable course. We could observe the orbit of the approaching missile, and we could determine the remainder of its orbit with the precise methods of astronomy.

Unfortunately, the defense can be frustrated by simple countermeasures. An incoming ICBM could be accompanied by a swarm of decoys, difficult to distinguish from real missiles. The decoys would draw the fire of our anti-missile missiles. Furthermore, there are ways of deflecting the course of a missile after it has been launched, so its path would not be predictable and it would not be such an easy target for an anti-missile missile.

Any problem of defense, including a defense against missiles, obviously must be considered from both sides. A defense is really good only if it is not much more expensive than the offense. And a defense is good only if it cannot be outwitted with ease. The process of offense and defense is a deadly game, the systematic development of answers to answers. If it is found in this process of move and countermove that the aggressor has the

easier and less expensive task, there is something basically wrong with the defense.

Establishment of anti-missile defenses today seems difficult and costly. Outwitting and defeating those defenses might be relatively easy and cheap. If this proves correct, it would be a mistake for the United States to build an anti-missile defense system at a huge cost. But we certainly must continue to look for a satisfactory missile defense system. Once it is found, we should try it out, and we also should develop methods to defeat the defense. We can be guided only by the results of this exploratory work. We cannot establish technical goals to correspond to our wishes. We must, instead, find out what is feasible by exploring the possibilities on a moderate scale. If we find that we can build an adequate anti-missile defense, we certainly should.

But if our anti-missile defense can be foiled, we should at least make sure that our retaliatory force can reach targets in Russia. Russia has the biggest rockets. She may well have the best nuclear explosives. It may be difficult to penetrate her rocket defenses. If the Communists should become certain that their defenses are reliable and at the same time know that ours are insufficient, Soviet conquest of the world would be inevitable.

In the past, we allowed guesses rather than hard exploratory work to guide our technical developments. This led to the missile gap. If we repeat this mistake, it may well lead to defeat.

The dangers of the missile age are great, and they are real. But there is one popular worry that is not so serious. It is not probable that satellites carrying hydrogen bombs will hang over our heads. This modern sword of Damocles, unlike the original, is not suspended; it does not remain in one place, but it travels. And it remains in orbit unless it is stopped. It is just as hard to stop a satellite as it is to get it started. To bring a satellite back to a precisely defined target would require a considerable load of fuel, a load weighing more than the bomb itself. To place

both the bomb and the additional load of fuel into orbit would require a much greater original amount of fuel. These considerations make attacks from satellites rather impractical. Why launch a missile from a satellite when it can be launched more easily and more effectively from the earth? A big, globe-circling launching pad, furthermore, could hardly be hidden. It would move fast, but as a rule it would be easy to predict its path.

Once a man-made object has started a long journey around the earth, it can be used more easily and more effectively as an instrument of peace than as a weapon of war. And in this peaceful field we have worked with diligence and with success.

Earth's atmosphere gets thinner at high altitudes. The last remnants of oxygen and nitrogen in the uppermost layers of air are exposed to those potent rays from the sun which never reach the earth's surface. The most energy-rich rays beyond the violet color of the rainbow tear the molecules of these gases into their electrically charged components, the electrons and the ions. At the very top of our air-cover, the atmosphere is replaced by the ionosphere.

All of this has great practical importance and has been known for quite a few decades. The electrons of the ionosphere reflect long radio waves and guide broadcast signals on their curved paths around the world. We are most acutely aware of this whenever radiation from the sun disturbs the ionosphere and radio signals fade.

Although we have known about the ionosphere for years, what was beyond we did not know. When our first satellites soared, we found out. James A. Van Allen and other American physicists discovered and studied great radiation belts surrounding our earth. In these belts the simplest charged particles, electrons and protons, spiral around the magnetic lines of the earth. These magnetic lines form a giant magnetic bottle, somewhat similar to

the little laboratory bottles in which we trap hot gases and try to control fusion.

The Van Allen belts worried us for a while. The fast electrons and protons have the same effects as the rays from radioactive materials. They can interfere with sensitive apparatus, and they can injure people. Fortunately, the walls of a satellite stop most of the electrons, and the rest of the radiation could be tolerated by a space traveler for a few hours. Effects of the Van Allen radiation, furthermore, are quite weak below an altitude of one tenth of the earth's radius and above the altitude of one earth radius; the space traveler could cross the danger zone in a short time.

The great radiation belts bulge out near the equator, but they are anchored in the ionosphere near the earth's two poles. They influence the polar lights and they have an effect on the manner in which the ionosphere guides the waves of radio broadcasts.

Our space explorations have helped us to understand the paths of radio waves. Now it is possible to do something about them. Shorter electromagnetic waves, like those carrying radar or television signals, are not naturally reflected back to the earth; they go right through the ionosphere. They do not follow the curvature of the earth. This is why coaxial cables or microwave towers are needed for coast-to-coast transmission of live television shows.

In the summer of 1960, we launched into orbit a light package which was inflated into an exceedingly thin-walled, 10-story-high silvery balloon. This was the Echo satellite. Bouncing back the rays of the sun, it shone like a bright star. But, more usefully, it also could bounce short electromagnetic waves back to the earth. Since an amazing amount of information can be transmitted by these shorter electromagnetic waves—more than enough information to affect the behavior of each luminous point on a television screen—satellites like our Echo can be expected to show the way to vast improvements in the world's communications systems. Such satellites probably will make world-wide

transmission of live television a reality. And if we put power stations into orbit, we could do more than merely reflect shortwave signals. We could amplify them. This could become important for long-range telephonic communications. The time may come when one can talk with anyone on the earth for an hour at the cost of one dollar. For better or for worse, all men will be neighbors.

Satellites may enable us to do something about the weather. Until quite recently, men had only an isolated worm's-eye view of the weather. They could look up at the sky and see whether the sun was shining, whether it was raining, and how fast the wind was driving the clouds at various altitudes. The first major advance in meteorology came with the telegraph, which permitted a speedy compilation of various worm's-eye views and the beginning of a systematized kind of weather prediction. During the last few decades, the air age has provided a bird's-eye view of the weather. This new dimension has given us a much better picture of the behavior of air masses, at least over the restricted parts of the world densely criss-crossed by airplanes. But aerial observations are infrequent over parts of the world where a great many weather changes originate. Our knowledge of the weather, as a result, is still sketchy and primitive. Satellites, for the first time, offer us an angel's-eye view of the weather. Proper instrumentation of a satellite will let us study the formation and movement of air masses simultaneously in the earth's entire atmosphere. This knowledge certainly will lead to much better weather prediction. It can be expected to lead to a better understanding and perhaps even control of weather.

The facts we have learned with the help of our weather satellite, along with all other scientific data gathered by our other space vehicles, have been made available. It is a striking fact that most of the original work in space research has been published

by Americans. We can be justly proud of this. But mere publication of facts does not necessarily mean that we have discovered more facts than the Russians. It may mean only that we are not as enamored of secrecy as they.

A satellite might be loaded with cameras and transmission equipment, implementing the "Open Sky" plan long proposed by the United States. This kind of inspection satellite could provide us with instant information about visible activities anywhere in the world. In an age in which a nuclear attack might begin and end within half an hour, immediate knowledge of world events surely is vital.

No matter how peaceful or beneficial their intended uses, all satellites would have important military applications. An Echo satellite could be used for much more effective military communications. Knowledge and prediction of weather could be used in limited warfare to determine the best times to drop men and supplies. An inspection satellite loaded with cameras and transmission equipment probably would be regarded by a nation objecting to aerial observation as a mechanical spy.

Because any satellite has military usefulness, I am afraid the day might come when the Communists would attempt to raise the Iron Curtain into the sky and shoot down our satellites. If that day does come, it will be necessary to fight for the freedom of space—just as it was necessary in the past to fight for the freedom of the seas. The United States must be prepared to fight this space war. If it comes, I expect it will be a limited war in the best possible sense. It will be limited in its objective: Freedom of space. It will be limited in its area: Space itself. And, best of all, it may be limited as no other war in history has been limited: There need be no deaths and certainly no mass destruction. The war for space will be a war of equipment and apparatus, of satellite and anti-satellite, of remote-controlled machine

against machine. The lives of millions of people and the destinies of cities will not be involved in the war itself, but only in the consequences of a defeat that would leave space as the province of an enemy.

Impractical space projects have always fired the public imagination and inspired man's sense of the romantic.

Some people, concerned about the population explosion on our crowded earth, look into the vast expanse of space and dream of colonization and interplanetary trade. Will this be the ultimate value of our space exploration? Will our children or their children become space pioneers and move their families to the moon or Mars or Venus? Will the people of the earth establish a long-distance commerce with space colonists, exchanging our manufactured goods for their valuable minerals? I think not.

Even if space colonization should one day be possible, it would be quite disagreeable. Mars would be the most likely location for the first space colony. It has a surface area about one fourth that of the earth and, more important, it seems to have a limited water supply that would be necessary for human habitation. The atmosphere of Mars includes a little oxygen—probably not enough for comfort but possibly enough to sustain human life. Colonists probably would have to master the art of shallow breathing. They also might change their way of walking; since Mars has less gravitational pull than the earth, colonists might find it easier to get around by leaping like kangaroos. One overriding disadvantage probably will keep humans from settling on Mars: It is cold. Humans could carry nuclear reactors to Mars as a source of energy and heat, but for comfort I definitely would prefer Antarctica.

I doubt that interplanetary trade ever will become a reality. Any mineral found in space, even gold or uranium discovered in the purest state, would not be valuable enough to justify the fantastic expense of shipping it back to the earth on freight mis-

siles. But there is something that we can bring back from space, a commodity well suited for long-distance transportation because it has no weight: Knowledge.

Until very recently the earth's atmosphere prevented us from seeing the universe in any wave length other than the limited spectrum between violet and red, which we call visible light. After World War II, an additional window on the universe was opened by radio telescopes. This new way of looking at the universe already has led to remarkable discoveries. It has enabled us to reach farther into the universe with instruments than we can see with the most powerful telescopes. In the depths of space, it has shown us the slow, gigantic drama of colliding galaxies.

Our space effort almost certainly will lead to establishment of astronomical observatories on satellite stations and on the moon. Once outside our murky atmosphere, powerful telescopes and radar equipment should be able to offer a clear picture of the universe, giving us more facts about the history and structure of stars and galaxies than we have ever known or imagined. We shall be able to look at the world in all wave lengths, from radio waves that are miles long to X rays that have wave lengths smaller than the nucleus of an atom. With this equipment operating in space beyond our atmosphere, we may even be able to determine whether heaven really is infinite or whether the universe, like the earth, is finite.

Our government has decided to put a man on the moon and to bring him back. President Kennedy hopes this can be accomplished "before this decade is out." We are racing the Russians to the first foothold outside the earth. We are planning to spend billions of dollars, and many people are asking: Will this money be wasted?

It is my firm belief that man will get to the moon and that he should get there. The moon will be only the first stepping-

stone in an inspiring adventure that will take us to every corner of our planetary system. The fascination that these plans have for our children is the most obvious and not the least important reason for this great adventure.

But there are additional, more concrete reasons for spending the large amounts of money required for this fantastic undertaking. A man in space can gather much more information than can mere apparatus. He can react to surprises in an intelligent way. He can handle unexpected situations. On the moon, he will be able to observe and ask questions that never would have been asked if human hands had not dug into the moon's dust.

The space astronomer, furthermore, will be able to work more efficiently on the moon than on a space platform. Wherever he happens to be in space, he will need energy. Atomic energy will be available to him. But atomic reactors need shielding, and shielding is heavy. To place one pound of material into orbit today costs $10,000. Even improved techniques will not cut the cost much below $1000 a pound. The heavy shielding required for an atomic reactor on a satellite would vastly increase launching costs. But an economical reactor shield already is available on the moon, for dirt on the moon will continue to be dirt cheap.

Astronomers on a space platform would require food, water, and oxygen. Everything needed would have to be sent up to them. A different situation would prevail on the moon. With energy from a dirt-shielded reactor, men on the moon probably could boil out from the materials of the moon all the water required. With the help of the same energy source, men could derive oxygen from moon materials and probably could produce carbon dioxide. With these ingredients and with sunlight, food could be grown. Men on the moon would be almost self-supporting. They would need the means for a return to the earth, some apparatus for explorations and self-support, a few vitamins and luxuries. But their sustenance would be moon-bound.

The moon could become a springboard for further space ex-

ploration. Water produced on the moon could be electrolyzed to produce hydrogen and oxygen that could fill the tanks of a rocket for travel over greater distances. Space vehicles, whether they run on chemical or nuclear energy, need such refueling. The slight gravitational pull of the moon would make it easy for a space ship to pull out of this space-refueling station.

Unfortunately, it is probable that Russians will be the first men on the moon. But the extension of man's knowledge to the planetary system will be a great event, and we must participate.

In exploring space, we will try to answer a question that is more interesting to us, as living beings, than any other: Is there other life in the universe?

There seems to be no life on the moon, where there is neither air nor water in the free state. We don't know about Venus, because its surface is hidden by the veil of an opaque atmosphere surrounding that planet. The existence of life on Mars is a distinct possibility. Looking at Mars with a spectroscope, scientists have found intriguing lines characteristic of the carbon-hydrogen bond—a bond that is found on the earth wherever there is life and in some substances such as petroleum that are remnants of ancient life. The existence of this combination of carbon and hydrogen atoms on Mars suggests the existence of life on Mars. But life on Mars may be so strange and so unusual in appearance that our first space explorers may not recognize it as life at all.

All living things on the earth—man, monkey, fish, amoeba, and even virus (which may not be alive)—are first cousins in the eyes of chemists; precisely the same complicated groupings of atoms are repeated in each one of them. We do not know what this complicated structure signifies. But we can put our limited understanding of life into a small capsule: Life is a little matter and a great deal of purposeful complication. I would like to know whether the Martian complication is similar to the terrestrial com-

plication. If it is similar, we may have a common origin. If it is different, our origins may be independent.

A search for any kind of life on Mars might prove disappointing. That particular planet might have no life at all. Even so, I am confident that the universe is teeming with life. Our sun is but one of a hundred billion stars in our galaxy. Many of these suns, surely, have planets. And some of these planets, like the earth, should be inhabited. Beyond our galaxy of a hundred billion suns, there are billions of other galaxies. Considering the immensity and age of space, I cannot believe that we are the only living beings. It would be very strange to believe that. It seems most unlikely that we are the only intelligent beings. It would be presumptous to believe that. The universe is probably ten billion years old, and life on earth has existed for only the last half-billion years or so. There must be others living and thinking.

Enrico Fermi, about ten years ago, changed the course of a luncheon discussion in Los Alamos with a sudden, simple question: "Where are all the people?"

Because his question had no connection with our previous discussion and because space exploration even then was on our minds, I guessed Fermi's meaning: There must be other beings beyond our planet with civilizations older than ours. Why hasn't their superior knowledge led to their exploration of our planetary system? Why have we been neglected by explorers from other galaxies? Why hasn't the earth been visited?

The answer to all these questions is distance. Our sun is in an isolated arm of our Milky Way, and it is quite easy to understand that no one has yet happened to come by this godforsaken neck of the woods. Distances from sun to sun immediately outside our planetary system are so vast that star-hopping may remain forever an impossible dream for man. Traveling at 186,000 miles a second, light requires four years to get from our sun to the nearest known star, Proxima Centauri. I doubt that man ever will travel to this star. According to Einstein, no one

can travel faster than the speed of light. No one can go even as fast as light unless he is divested of all weight and mass. But men are clever: We someday might build a lightweight rocket powered by nuclear fusion that could carry a man at one twentieth the speed of light. Even then, a traveler would take eighty years to get to Proxima Centauri, and, considering man's life span, this is a discouragingly long time.

But I would expect that men someday will be able to send some very light apparatus to Proxima Centauri. Light equipment would need proportionately less fuel to get it there. The rocket would not be as heavy as a man-carrying vehicle; it would not have to return to the earth; and the undertaking would not be as gigantic. Still, three generations of scientists would have to wait on the earth for the equipment's first reports.

Interstellar traffic is not nearly as difficult in other parts of the universe. In the core of our own galaxy, 30,000 light-years away, the stars are much closer together. In that core, it is quite possible that people from different stars already are exchanging information and even colonizing other planets. From our suburban isolation we can hardly expect to reach the metropolitan center of our galaxy, but we might be able to launch radio equipment into space—beyond our reception-blurring atmosphere—where we could listen on all wave lengths. Then, if there are intelligent beings at the core of our galaxy, we would have a chance of listening in on their radio broadcasts. We might hear and decipher interesting interstellar discussions or receive disturbing news about interstellar wars. But the news, of course, would be 30,000 years old.

As distances are measured in space, the center of our own galaxy is relatively close to the earth. The closest galaxy similar to our own, Andromeda, is much farther away—almost two million light-years from the earth. And beyond Andromeda, galaxy follows galaxy at similarly great intervals to distances of billions of light-years from the earth. Light just now reaching us from

some distant galaxies may have started its long journey when the world was quite new. The human race will be excluded forever from even the nearest galaxy.

Forever, though, is a long time. I have no realistic hope that we can reach Andromeda, but men 500 years ago had no realistic hope that they could hurl rockets around the world. And since progress breeds accelerated progress, the wildest dreams of today might be realized within only a few centuries.

There is a faint and fantastic hope of being able to develop the kind of powerful, long-lasting source of energy needed to propel a capsule far into space. We might use anti-matter. Each particle of matter has its opposite in anti-matter, and we know we can make anti-particles of all kinds. When matter and anti-matter meet, they consume each other and transform themselves into pure energy. Because it is so extremely efficient, this technique of producing energy is the best source of power for interstellar travel.

But the use of anti-matter also presents an obvious problem. There may be no way of containing anti-matter, since any vessel necessarily would be constructed of matter and would disappear as soon as it was touched by anti-matter. The problem of containment, however, might be answered by the magnetic bottle since magnetism and anti-magnetism are the same. The lines of force of a magnetic bottle could contain anti-matter as well as matter. The idea of filling a magnetic bottle with matter and anti-matter and using it as a spaceship's source of power may appear harebrained. But at least it does not contradict the laws of nature, so who can say that it never will be feasible?

Suppose it can be done, and suppose that we try to get to Andromeda. Let us say that light requires two million years to travel from here to Andromeda and, although Einstein proved that we cannot do it any faster, Einstein's theory of relativity allows some hope that someone, someday, might get to Andro-

meda without having his life span prolonged almost indefinitely.

Scientists and engineers working very hard for a few hundred years could conceivably develop a vehicle and a means of propulsion that would allow man to go almost as fast as light. Suppose we put an astronaut in this vehicle and shoot him off toward Andromeda. The time required for him to get there would be relative; it would have one duration for him and a different duration for the people he left behind on the earth. This difference, to a space traveler, would be most important. And it can be determined in advance.

Einstein showed that although the time difference does not remain the same for all observers—and this is a most surprising but true statement—another quantity does remain the same for all. This quantity can be called Q, and it can be calculated with the help of a simple formula. Take the distance (ct) that light moving with the speed c could have covered during the observed time difference t between take-off and landing; multiply this length by itself, giving $(ct)^2$. Then take the distance between take-off and landing, call it R, and multiply that by itself, giving R^2. Subtract one from the other for the quantity: $Q=(ct)^2-R^2$.

This Q remains the same for all observers, and this proven rule of Einstein's is important.

Observers on the earth would see the rocket heading toward Andromeda almost as fast as light. The rocket would appear to take just a little more time than light would have taken to reach the distant galaxy—slightly more than two million years. The distance actually traveled between the earth and Andromeda would be, let us say, precisely two million light-years. So the difference —Q—between the two huge quantities—$(ct)^2$ and R^2—would seem quite small to people on the earth, since the astronaut's rocket traveled the distance almost as fast as light.

The difference—Q—will be the same for the astronaut. But he will have to use different figures in the rest of his formula. His world will be his rocket. In this world he will remain stationary.

He will depart from the earth and arrive at Andromeda in the same position: at the controls of his spaceship. He will have to say that he did not move, but that the universe moved past him. He must say, therefore, that the distance he actually covered between his departure and arrival—*R*—is zero. This will be fully valid and justified, and this is an important point in Einstein's work. The astronaut will feel the same as you feel on our whirling planet: The sun rises and sets and the universe moves around you, but if you are sitting still you do not move.

The difference—*Q*—must be the same for the astronaut as for the earth-bound observers. Since *Q* appeared small for the people on the earth, *Q* also must be small for the astronaut. But since the distance covered by the astronaut between take-off and landing—*R*—seems to him to be zero, the time required for the flight will seem much shorter to him than to people on the earth.

To the astronaut, the rocket flight from the earth to Andromeda might seem to have taken perhaps only twenty years. To observers on the earth, the same flight will seem to have taken a little more than two million years.

Suppose the astronaut spent ten years exploring the galaxy of Andromeda and then returned to the earth. He would expect a hero's welcome, a ticker-tape reception in New York, and a high decoration from Congress. Far from it. He would be only fifty years older than when he began his historic flight, but the earth would have aged more than four million years. All his friends and relatives would be dead. No one would speak his language. He would find the world inhabited by a strange race that he would consider horribly deformed, but which in reality would be far superior to his own both in understanding and in intelligence. They would undertake the scholarly task of deciphering his notes. And when his wild tale of a space flight begun four million years before had been confirmed by archaeological investigations, this new arrival, this astronaut, this specimen of an ancient and extinct race would be put in a zoo.

Space has its dangers. Even fantasies about space seem to end tragically. But fact and fiction about space do remain interesting and inspiring. For our children, no topic holds a greater fascination. And the kindling of young curiosities may well be the most important consequence of our adventuring into space.

CHAPTER EIGHT:

Seeds of Tomorrow

AT THE END OF WORLD WAR II, the leadership of the United States in technology and science was unquestioned. America's daring and practical spirit of enterprise was legendary. To bigger and better engineering, we had recently added brilliant and fantastic scientific discoveries. We excelled all others in the quality and quantity of our scientific research and in our technical ability to utilize new scientific facts. Never before in the history of the world had the men of one nation assumed such power over nature. The scientific leadership of the United States was universally recognized and admired.

That leadership today is in doubt. We have been challenged by a formidable competitor: The Soviet Union.

In 1945, many thought of Russia as a country inhabited by backward peasants. Russia's progress in many fields of science and technology during the last decade has changed that image. In the spectacular fields of aviation, atomic energy, and space exploration, the Soviet successes have been particularly great. The dramatic swiftness of Russia's rise in the practical sciences has had an immeasurable effect upon the world's opinion of Communism. Applause for Communist science in many parts of the world is applause for Communism itself. Russia's progress has created an admiration for the Communist method, especially

in the world's backward countries that aspire to the same swift progress.

Bootstrap progress that carries a nation from a low level of scientific accomplishment to a position of scientific challenge or dominance is most difficult to achieve. When such progress is achieved, it demands respect. It could not have been achieved in the Soviet Union if the Russian leaders and people, after their revolution against czarist rule, had not been motivated by an overriding ambition. And the strong motivation would have gone for nothing without tremendous improvements in Russian education.

Soviet scientific successes are recent. But the arduous work leading to those successes has been going on for decades. The fountainhead of Russia's impressive technical strides has been the incredibly rapid improvement of technical schooling. All the amazing Soviet scientific-technological advances have stemmed from the Russians' post-revolution determination to achieve better education. The accomplishment of Russian teachers probably has been the most impressive feat performed behind the Iron Curtain.

A great battle has been won by the Soviet Union in the schoolroom. We now are becoming aware of the consequences of this victory. But what we have seen so far is only a beginning. We had less foresight than the Russians in improving important segments of education, and the consequences will be increasingly advantageous to the Communists for years to come.

The education of a scientist takes many years, and the best scientific minds are the youngest minds. The majority of scientists do their most important work and make their most valuable contributions before they are thirty. Scientists who will have reached this age of greatest productivity in a decade are students today, and more students today are being given a better scientific education in the Soviet Union than in the United States. I think that in ten years Russia will be the world's recognized scientific leader.

Although we cannot hope to retain our scientific leadership, we can hope to regain it. We shall be able to catch up with the Soviet Union and once again establish our scientific leadership only if we begin now to improve the education of our children. If we are to have a plan, a purpose, and a hope for tomorrow, we must plant the seeds in the schoolrooms today.

The importance of improving both the quantity and quality of scientific education in this country cannot be overemphasized. Progress in science is exciting and admirable no matter where or how it occurs, but in these fateful years Soviet advances must be matched. Today's science is tomorrow's technology. Science is needed for a better and a more abundant life, but it also is the foundation of modern military strength. Science can help the Soviet Union win the world either directly, by giving the Communists supremacy in weapons, or indirectly, by producing the tools for economic penetration and by commanding admiration for Communist know-how and for Communist methods from the world's uncommitted nations. If we do not act now to educate our children and prepare them for the task of reclaiming scientific leadership for the United States, there is no doubt in my mind that before the end of this century the world will be modeled after the Communist plan and not after our own ideals of liberty and respect for the individual.

Our preschool children today are ready and eager for a scientific renaissance. Their young imaginations and curiosities are soaring into space. They see the results of science everywhere; they are fed, clothed, moved, and amused by technology. American children are more interested in science today than ever before. It is vital that we nurture and encourage this interest. If we allow it to die, our way of life will die.

The Soviet Union is winning on the battlefield of the schoolroom for two primary reasons: Russian children are more anxious than American children to become scientists, and the Soviet government has simplified education.

Russian children know, as soon as they are old enough to learn anything about their society, that a scientist in the Soviet Union is a privileged person. Scientists in Russia have all the honors, all the comforts, all the security that the country can offer. This means a great deal in Russia, where so many have so little. A Russian child realizes, early in life, that he will be comfortable only if he becomes a politician—and a successful politician, at that—or a scientist. And he can be secure only if he becomes a scientist. Ambitious youngsters work hard to become scientists, because only in science can they hope to achieve acclaim, comfort, and security.

Children in the United States are not attracted to science for these reasons, because scientists in America do not occupy such a privileged position. They are, in fact, considered outside the society.

The United States is the most complete democracy the world has known. Our nation is much more than a political democracy. We also are democratic economically and intellectually. Our industrial production is for the masses. Books are written for the masses. Magazines are circulated among the masses. Movies are produced for the masses. Radio and television programs are beamed toward the masses. Politicians appeal to the masses. Baseball games, football games, basketball games, wrestling and boxing matches, horse races, and all other sports events are staged to delight the masses. The crowd decides what is good, and the crowd's value judgments—expressed in sales or box-office receipts, measured by pollsters, revealed in voting booths—control every segment of American life.

This is as it should be. But the very virtues of democracy create some American shortcomings. Science, music, art, or any other intellectual achievement requires certain habits and tastes that are not inborn, but acquired. The best student, the young poet, the budding engineer, the person inclined toward serious theater or classical dance—all acquire value judgments different from those of the majority; so they are not as popular as the

football player or the movie starlet. If, after some years, the intellectual in America achieves an outstanding success, if his accomplishments are spectacular and well publicized, he may find himself on a pedestal. But he never is accepted by the crowd, and he never is understood. He is called a highbrow, an American epithet that defies translation into English or any other language, connoting a peculiar authority and gentle ridicule.

The people seem to say to the intellectual and especially to the scientist: "Go ahead and play, but please leave us alone." Now a good scientist is in love with his work. He could not otherwise continue to make the long and difficult effort needed to bring order to an unexplored patch of the intellectual wilderness. So, as he sees the common man turn his back, the scientist also withdraws. He seems to say: "All right! You call me a highbrow, so this is precisely what I shall be. I am interested only in my intellectual associates, and we will talk to each other in scientific polysyllables which only we understand. Sometimes I wonder whether anyone understands them but myself."

A chasm separates the common man from the intellectual in our country. It has impaired our strength and it has fragmented our science. The intellectual, deprived of an audience, has lost the knack of talking to intellectuals in fields other than his own. Our intellectual community has been split into many highly expert cliques. Our leaders in science, art, and literature indeed have been turned into highbrows. They have gathered on mountain peaks of specialized interests. They have lost contact not only with the common crowd but also with each other.

I was painfully reminded of the isolation of scientists by a politician whom I saw during the campaign of 1956 on a television program. He was a good politician, running for office, and he knew enough to say nothing that was not popular. He was asked a question about radioactive fallout. I do not remember his reply, but I do recall his first words: "Of course, I know nothing about nuclear physics, but . . ." Had he been asked

about legislation to prevent the bribery of athletes, I cannot imagine that he would have prefaced his reply by saying: "Of course, I know nothing about baseball, but . . ."

This situation saddles the United States with a dangerous disadvantage in the education of future scientists. Children in the Soviet Union know that if they become scientists they will become privileged and secure individuals in Russian society. Children in the United States know that if they become scientists they will be called "squares," "double-domes," and "eggheads"; they will place themselves outside society. Rather than travel the hard road of the nonconformist, our children are more inclined to seek society's acceptance as businessmen or as members of the established professions of law, medicine, or clergy. Our really ambitious children might seek the fame and fortune that the crowd heaps upon such national heroes as television actors and rock 'n' roll singers.

In addition to making science attractive as a vocation, the Soviet government has simplified education.

A few months after the Bolshevik Revolution in Russia, the Commissar for Education, Lunacharsky, issued an order that abolished three letters from the Russian alphabet. Before that time, Russian words were spelled almost—but not quite—phonetically. Three sounds of the language could be written in either of two ways. Lunacharsky decided it was confusing to have alternative ways of spelling these three sounds, so he eliminated the need for selection by abolishing the three superfluous letters. Only one way to spell the three sounds remained, and the Russian language became completely phonetic.

A very few weeks after a Russian child enters school, the world of books begins to open up for him. This is a wonderful experience, and the wonder is lasting. Hungarian spelling, like the original Russian system, is largely phonetic. I had no difficulty in learning to read. I still remember, as a matter of fact,

the thrilling experience of reading my first book; it was the story of two Hungarian puppies. Few Americans, I have found, remember reading their first book. This is natural, because students learning to read in the United States hardly experience a thrill of accomplishment. Learning to read words that have groupings of letters unconnected to the sounds those letters would make if pronounced is a formidable task—a chore better forgotten than remembered.

The Soviet government in 1927 did for arithmetic what Lunacharsky had done for the alphabet. Russia abolished the last remnants of historic but absurd measurements and completely adopted the metric system, a method of measuring everything in simple multiples of ten.

The metric system is not a Russian product. It was created by an earlier revolution and was adopted in France in 1791. But Soviet leaders were wise enough to see the advantages of the metric system and foresighted enough to put those advantages to use.

Metric measurement is based upon the meter, representing one ten-millionth of the distance between the earth's equator and pole. No other system of measurement is so simple, so clear, and so universal. Two lengths multiplied give an area. An area multiplied by a third length gives a volume. For students using the metric system, a start in geometry is easy and progress in physics is not made unnecessarily difficult.

The metric system is the arithmetic language of the scientific laboratory. Young Russian students who understand and use this system from the time they first learn to count have an obvious advantage in their education as scientists. Metric arithmetic is a window through which Russian students get their first glimpse of the simple orderliness of the world. They are stimulated to look further. Their interest in science is aroused, and they soon

are prepared to get acquainted with the puzzles of the universe in which we live.

American students, by comparison, have a difficult time. From their early struggles with reading and spelling, our youngsters get the impression that education is arbitrary, difficult, and boring. This impression frequently hardens into a real dislike for learning by the time a child suffers a head-on collision with our confusing and forbidding method of measuring length, volume, and weight. He is told to measure length by miles, area by acres, and volume by gallons. There is no logical connection between these units. The words we use to describe length and area do not suggest to a child the simple truth that by multiplying two lengths he can get an area. Before he can begin to measure length, area, and volume, the American student must learn by rote that there are twelve inches in a foot, three feet in a yard, five and one-half yards in a rod, 5280 feet in a mile, 640 acres in a square mile, and either two pints or thirty-two ounces in a quart. In measuring volumes, he has the choice of using gallons, bushels, pecks, cords, or barrels, as well as the somewhat more reasonable cubic foot which contains 1728 cubic inches. These English units make an American child work like a Roman trying to figure out why XVI times LIII equals DCCCXLVIII.

Some of our most impractical measurements hide the simple, natural connection between length, area, and volume. They erect an artificial barrier that often diverts, blunts, and frustrates a youngster's interest in science.

Eventual simplification of our language to a phonetic system may be impossible. But eventual simplification of our methods of measurement to the metric system definitely is possible, and this simplification would help to eliminate one of the walls now standing between a child and science.

The United States should adopt the metric system. We have come closer to this goal in recent years than most Americans realize. Lewis Strauss, as President Eisenhower's Secretary of

Commerce, planned to ask the Bureau of Standards to investigate the best way to achieve a gradual but speedy transition of the nation's methods of measuring to the metric system. Introduction of the metric system would have many advantages outside the field of education. Most of the world now uses metric measurement. The competition for world trade is becoming keen. The nation that can deliver machinery and products measured in terms that most of the world's people can understand easily, eliminating arithmetic barriers to reorders and replacements, will be in a more favorable commercial position. But Strauss' appointment as Secretary of Commerce was not confirmed by Congress, and early adoption of the metric system in our country suffered another setback.

The United States, of course, could not adopt the metric system overnight. But we could start teaching our elementary school children the metric units of measurement right now. Children could be told about inches and feet and pounds, but these clumsy measurements should be presented as if they were about to be abandoned.

A good second step might be to erect new road signs and print new maps, giving geographic distances in kilometers rather than miles.

A third step might be to set a target date after which metric units would be used in all legal and governmental documents, providing an accumulating pressure for general adoption of the metric system. At the end of perhaps five years, all government orders for materials and supplies might use the metric system in the specifications, literally forcing companies dealing with the government to adopt metric measurement.

Our nation's complete change-over to the metric system probably would take a long time, perhaps a full generation of thirty-three years. Precisely because full adoption would require many years, we should initiate an exhaustive study of the possibilities and consequences of adoption now.

exceedingly small. The bones of humans throughout the world today are getting an average of about 0.002 roentgens a year from Strontium 90 in the fallout. The rest of the body is being exposed to about the same amount of radioactivity, mostly from the fallout's Cesium 137. In certain areas there is a greater accumulation of fallout, but it would be difficult to imagine that anyone in the world could receive a lifetime dose of more than four or five roentgens of radiation from fallout. This still is less than radiation received from cosmic rays alone.

We found it enlightening to compare the human exposure to radioactive fallout with the human exposure to natural background radiation. The same doses of radiation from fallout's Strontium 90 and from cosmic rays will produce similar effects in human bones. People living at sea level in the United States are exposed to 0.034 roentgens of radiation from cosmic rays each year. This is seventeen times the amount obtained from the Strontium 90 in the world-wide fallout. Exposure to cosmic rays in Denver, about 5000 feet above sea level, is 0.05 roentgens a year. If such small doses of radiation really were dangerous, we had better evacuate Denver.

Radiation from radium is somewhat more dangerous to the human body than radiation from Strontium 90. But while world-wide fallout radiation to the bones from Strontium 90 continues at a dose of about 0.002 roentgens a year, radiation from radium in the drinking water in some parts of the United States has been observed as high as 0.005 roentgens a year. If such small amounts of fallout radiation really are dangerous, people in some United States communities should stop drinking their local water.

Brick contains more natural radioactivity than wood. A person living in a brick house rather than a wooden house is exposing himself to a considerably greater amount of radiation—perhaps as much as ten times the amount of the current dose from radioactive fallout. If fallout really is dangerous, we should tear down all of our brick houses. I would hate to do this, because I live in a brick house myself.

The comparisons are almost endless. A person wearing a wrist watch with a luminous dial is exposing himself to much more radiation than he is getting from the present level of radioactive fallout. If we really fear fallout, we should throw away bedside alarm clocks with dials that can be seen in the night because they are spraying the occupants of the bed with radiation.

If we had used natural background radiation as the standard in judging the danger of exposure to artificial radioactivity, the fallout scare might never have developed. Unfortunately, this was not done. Instead, arbitrary standards were decreed, and to make them safe they were set at a rather low level.

Radiologists in the early 1940s, taking their cue from the hard experiences of medical pioneers, considered one tenth of a roentgen-unit a day as the dose which for safety's sake should not be exceeded in steady practice. This was based upon observation. No statistical evidence could be found that a steady exposure to one tenth of a roentgen a day produced any harmful effects. This old standard of safety permits exposure to 10,000 times as much radiation as the average person now receives from world-wide fallout.

This medical standard at first was adopted in our work on atomic energy. I remember the first information I was given when I joined the atomic energy project in Chicago in 1942: "You must never exceed an exposure of one-tenth of a roentgen-unit a day. As long as you observe this rule, you are safe." As a theorist, I had little occasion to be exposed to radiation. But the general enforcement of radiation standards paid off in our atomic energy projects. We had no sad experiences comparable to those of the early medical pioneers.

Serious arguments later arose about possible long-range dangers of radiation exposure. The dosage accepted as safe, accordingly, was decreased to three tenths of a roentgen-unit per week. This standard still is several thousand times higher than the ex-

posure to world-wide fallout. No harmful effects were observed, and this standard generally continues to be enforced in our laboratories.

But a question was raised: "When we consider whole populations rather than small numbers of professionals, should we not apply more cautious standards?"

The question appeared reasonable enough. It was decided that for whole populations only one tenth as much radiation should be tolerated as for small professional groups. This decision was completely arbitrary. It was based on no observed fact or general argument. It was guided by a desire to be absolutely safe even though we were virtually certain that these faint radiations were not dangerous. The authorities in subsequent years, trying to make safety multiply safety, further decreased this so-called "maximum permissible dose."

This designation, "maximum permissible dose," was most unfortunate. It suggested that anyone receiving more than this dose was in trouble. When, due to a local fluctuation, a small group of people received a sizable percentage of this "maximum" dose, there were feelings of alarm. When the "maximum" standard was lowered, there were feelings of uncertainty and distrust. Thus public confidence was lost, and exposure to small doses of radiation was firmly established as dangerous in the popular opinion.

The fact is that the "maximum permissible dose" is approximately four times the background radiation to which all living things have been exposed for all time. An exposure to ten times the "maximum permissible dose" certainly can be tolerated.

I do not propose that we relax our vigilance in guarding against possible dangers of radiation. But I do propose that the man-made and arbitrary "maximum permissible dose" should not be used as a measure or standard of danger. We should, instead, compare all exposures to the average background radiation. This radiation is a fact of nature. There can be little disagreement about its magnitude or its significance.

Probably there is no major United States scientific advance of which the Russians are ignorant. Still, the United States persists in spending millions of dollars a year to maintain a rigid scientific-technological secrecy.

The cost of maintaining secrecy in this country is high because the amount of secrecy is large. I cannot say just how many secrets the United States is trying to keep. Even that is secret.

Our concern, however, is not the amount of secrecy or even the cost of secrecy, but the fact of secrecy and the effects of secrecy.

The effect of secrecy upon our scientific development is ironic. Because we try to keep a potential enemy from knowing what we know, we know less ourselves. In a free country like the United States, people do not like to work in secret. By its very nature, secrecy involves rules and regulations that impinge upon freedom. Scientists, like anyone else, dislike regulations and restrictions. So scientists prefer to work in areas free of secrecy, where the interchange of ideas is encouraged and where they can become known for their achievements. By repelling some of our best minds from work that is badly needed for our defense, secrecy has performed a disservice to our nation.

Russian secrecy does not have the same effect upon Russian scientists. Secrecy was firmly established under the czars as well as under the Communists in Russia. Scientists working outside nuclear projects are just as restricted and as regimented as those who are engaged in these high-priority efforts. So Russian scientists are not tempted to abandon military efforts for the sake of personal freedom, because personal freedom simply does not exist.

Since the United States no longer has a nuclear monopoly, our safety no longer lies in keeping all we know to ourselves. Rather, our safety depends upon the rapid conception and utilization of ideas. The United States and Russia today are competitors in several races: The race in atomic energy, the race for space, a

race for men's minds, a race to influence uncommitted nations, a race for national defense and survival. These are races of ideas, contests of the mind, and the winner of each race will be the nation which is the fastest producer of the best ideas. Because free discussion encourages progress and usually improves ideas, I believe less secrecy would mean more speed in our race for new and useful ideas. And the United States needs more speed in the races which vitally concern our freedom and survival.

Exaggerated nuclear secrecy not only slows our scientific development, but it also stands as a barrier between ourselves and our allies. Secrecy has forced the United States to assume the ridiculous posture of denying to our friends facts that are known to our enemies.

The United States has taken several significant steps to reduce nuclear secrecy, especially between ourselves and our allies. We published the relevant principles of reactor construction in the Smyth Report as early as 1945, and we took the initiative in revealing essential methods of reactor technology at the 1955 Conference on the Peaceful Uses of Atomic Energy in Geneva. The Atomic Energy Act was liberalized in 1958 to allow even more discussion of nuclear secrets with our allies. All this has helped alleviate the problem of nuclear secrecy but has not eliminated it. The barrier of secrecy still stands between ourselves and our friends, resulting in a duplication of effort, a waste of time, and a waste of money.

Our policy of continued secrecy, for example, forced the French to make an independent effort to explode atomic bombs. Surely it would have been wiser for the United States to have shared nuclear secrets with the French and freed France's scientists from the time-consuming rediscovery of facts and methods already known to us. The cause of freedom would have been advanced if our nuclear secrets had been used to unite rather than divide, if the considerable talents of French

scientists had been utilized in a common undertaking aimed at increasing Western security rather than devoted to the rediscovery of known facts.

The disservice performed by secrecy in erecting artificial barriers between friends cannot be overestimated. We live in a time that demands common action among the free nations in the building of a lawful world community. It is self-defeating to permit nuclear secrecy between friendly nations to hamper cooperation.

Aside from creating a moral disunity among free nations and suggesting that the United States really does not trust its allies, our continuing policies of nuclear secrecy seriously weaken the West's defense against World Communism. We have convinced ourselves that we should not discuss all of our nuclear weapons even with our allies. The United States has weapons in its arsenal and on its drawing boards that have never been disclosed to friendly nations bound to us by treaties of mutual defense. Since secrecy is contagious, it is not inconceivable that these same nations may have developed some weapons that have never been discussed with us. I think we cannot expect the North Atlantic Treaty Organization countries to develop the best plan of mutual defense when the instruments of defense are not fully known to all NATO countries.

It is not enough to give our NATO allies some of the nuclear weapons we have developed and constructed. We also should discuss with them our future plans. Adaptation of a military organization to advances in weaponry often requires more time than development of the weapons themselves. If NATO nations are kept ignorant of advances in nuclear weapons, if they cannot plan ahead, NATO's military organization cannot be expected to make effective use of new weapons when they are developed. Our NATO defense cannot realize its full potential as long as we keep our nuclear plans and nuclear secrets to ourselves.

Free and open discussion of our nuclear work would cer-

tainly strengthen both the military defense and the political unity of the free world. To the extent that our secrecy isolates free nations from one another and creates suspicions between allies, it certainly performs a disservice.

Secrecy's most insidious danger, however, is to our own form of democracy. A bulwark of our system of government is the people's right to know. Secrecy, in effect, denies that right.

We have instituted safeguards which, to some extent, will prevent the subversion of democracy by our policies of secrecy. We have made our nuclear effort the responsibility of a civilian rather than a military agency. And the Atomic Energy Act recognized the danger of entrusting our atomic program to any single agency, civilian or military, functioning in complete secrecy. To avoid the dangers of centralized, secret power, the Joint Congressional Committee for Atomic Energy was established. This committee balances the power of the Atomic Energy Commission by making critical reviews of all important decisions. The committee and its staff—none of them scientists—have done a remarkable job of understanding, appreciating, and criticizing the complex field of nuclear technology. The committee and the commission constitute a team that often has been harmonious and almost always has been effective. Members of the congressional committee are empowered to penetrate the aura of secrecy that surrounds all nuclear matters and judge nuclear decisions and progress as representatives of the people.

But public representation, in this case, is not the same as public participation. Neither is it as effective. No matter how well the public's elected representatives perform their duties as nuclear watchdogs, a better system of checks and balances would be provided by an informed public opinion. The government often cannot act effectively without public support. It frequently cannot act wisely unless the public is informed. It must act either

arbitrarily or unwisely if the public is misinformed. And secrecy breeds misinformation.

Misinformation has indeed flourished and multiplied in the postwar years. Secrecy is not entirely to blame. The American public has assumed that questions of nuclear energy and nuclear explosives are beyond the understanding and judgment of the average individual. Most people believe that these difficult questions should be left to the expert.

Besides, these problems are not merely difficult. They also are disagreeable. They force one to think of war, of nuclear conflict, of Hiroshima, of things that would be more comfortably forgotten. Better leave all these questions to the expert.

I cannot escape the suspicion that this public attitude is somewhat analogous to the behavior of an individual who has a disturbing problem. It is not unusual for such people simply to ignore their problem; the disturbing fact is shoved aside, forgotten. Psychologists have an expression for this phenomenon: Repression. And repression is not a sign of mental health.

Analogies are incomplete and even dangerous. But it seems to me that secrecy has become a psychological defense mechanism for a considerable segment of the American people. Secrecy is the vehicle of repression. It helps to make it possible and even necessary to forget what most people prefer not to remember.

Thus a great burden of responsibility was offered to the expert scientists, to a group which happened to live outside the main stream of American life. The responsibility was greater than that carried by any other group of citizens—with the single exception of the elected representatives of the people. And what did the experts do with the considerable share of responsibility that was thrust upon them? They did what most people would have done in similar circumstances. Many of the experts gladly accepted these responsibilities. They felt that scientists, the most intelligent of all citizens, had been entrusted with their due, the responsibility for important decisions that they could handle more capably than anyone else.

These attitudes and consequences have created a situation in which the common people, the sovereigns of our democracy, have abdicated. The right to know is a basic institution of our democracy. More than that, it is an obligation of every citizen. As long as governmental secrecy denies that right, as long as secrecy spawns a public indifference to that right, as long as most of our citizens ignore the obligation to know and leave vital decisions to be made by an elite of "experts," our secrecy is a threat to our democracy.

In addition to the experts, another, incompletely informed group participates in the molding of American public opinion. This group includes newspaper and magazine editors, reporters, commentators, columnists, clergymen, teachers, authors, government officials—almost anyone who has an audience and who has something to say. These opinion makers have continued to shape the public mind despite our government's official policy of nuclear secrecy, despite their exclusion by secrecy from knowledge of vital decisions and developments, despite the obvious limitations imposed by secrecy upon intelligent discussion. The result has been a misinformed public opinion still exerting its traditional influence on the formation of important national policies. This has been dangerous and could be disastrous.

Several recent examples can be cited of public opinions that were uninformed or misinformed and so led to trouble. The AEC, in its constant review of secret material, had declassified all of the facts about radioactive fallout before Democratic candidates made this topic the issue in a public debate during the 1956 presidential campaign. But because the facts once had been secret, the suspicion persisted that perhaps the government had not told all that was known about fallout dangers. This suspicion paved the way for the excited and unsupported predictions of some scientists that fallout could kill thousands of the living and make future generations grotesque. The result was a national bath in the emotion of fear that became known as the

fallout scare, and a misinformed public opinion demanded that we halt nuclear tests.

Another example arose during the Geneva negotiations on test cessation. In the early months of 1959, we proved that underground nuclear explosions could be muffled and hidden from detection. But this knowledge was withheld from the American people, and the public opinion was allowed to form that violations of a test ban treaty could be detected and identified anywhere in the world. The detection difficulties were revealed to the American people by our government only after they had been discussed with Russia. And, by then, it was almost impossible to focus public interest on the technical difficulties and change the established and prevailing public opinion that, in safety, we could agree to ban all nuclear explosions. Our people could not have been misled and the public opinion would not have been wrong if all the facts had been available to all the people all the time.

Even today, a sound and rational public opinion on the need for certain nuclear weapons is greatly impeded by secrecy. And because the public cannot be fully informed of the need, public opinion cannot be aroused to the point of demanding the weapons. There is an urgent need for better tactical nuclear weapons. These weapons, I believe, must be developed as the tools of limited nuclear warfare. Beyond this, I can say little. Because of secrecy, I cannot be explicit. I suspect that Russian leaders know more about our nuclear weapons plans than do the American people. Our own policy of secrecy allows only a superficial description of our weapons needs for the benefit of our own people. Secrecy makes it difficult to awaken Americans to the real dangers and real opportunities of our atomic age.

There are two popular and powerful arguments for continuing nuclear secrecy.

One argument is that if we did not keep our nuclear secrets,

more and more nations would produce nuclear weapons. This argument once had merit; today it has little. We could find assurance in our nuclear secrets only as long as we had a nuclear monopoly. But that monopoly has been broken, and every nation with the materials necessary for a nuclear explosive has succeeded in making a bomb. Production of the explosive materials is somewhat difficult, but they can be produced in any nuclear reactor. Since the United States published reactor principles in 1945 and revealed essential portions of reactor technology in 1955, there is little reason to believe that even a small nation willing to spend the time and money would be unable to put together a nuclear bomb. The number of nations winning membership in the group known as the Nuclear Club certainly will increase. Despite our zealous secrecy, more and more countries will achieve a nuclear capability. This is inevitable. We should realize now that when this inevitable development occurs, when additional nations that are both friendly and unfriendly succeed in constructing nuclear weapons and the means for their delivery, our policy of secrecy then might perform its greatest disservice. If we persist in nuclear secrecy, the nuclear capabilities of additional countries will certainly be developed in secret. This could lead to a tragic and perhaps fatal misjudgment on the part of the United States. Suppose a small but ambitious nation developed just one atomic bomb in secret and fired it upon a target in the United States. We would retaliate, but most likely against an innocent party, and the misjudgment prompted by secrecy could plunge the known nuclear powers into an all-out war. World-wide openness would greatly decrease the possibility of such a tragic error.

The other argument for continuing secrecy is more valid: If we tell the world our nuclear secrets and the Russians keep theirs, it is obvious that Russia always will be ahead of us.

This is a serious argument. If we abandoned scientific secrecy completely and Russia did not, the Soviet Union surely would have some advantage. But the degree of that advantage is ques-

tionable. It certainly would be a short-term advantage. Nations at about the same stage of technical development usually discover the same technical facts at about the same time. General scientific principles can be kept secret for only a very short time, because secrecy of itself does not prevent the spread of ideas or their rediscovery by scientists of other nations. When two or more parties have reached about the same level of development, scientific secrets remain secrets for only a couple of years.

This, then, is our dilemma: If we should abandon nuclear secrecy, we would give the Communists some advantage. If we retain secrecy in its present form, we slow our nuclear progress, erect a barrier between ourselves and our allies, force a deplorable duplication of time and effort upon the building of a common Western defense, and impede the formation of a well-founded American public opinion. There is no question, in my mind, that secrecy's service in giving us some scientific advantage is transient and limited. Secrecy's disservices, on the other hand, seem to me to be cumulative and substantial.

Important steps have been taken toward elimination of secrecy. But more should be done. At the very least it is necessary to apply our rules of secrecy in a more liberal manner. A more radical and persuasive suggestion has been made by Niels Bohr, a man who has always opposed secrecy in scientific matters.

Shortly after the end of World War II, Bohr suggested that scientific openness would be to the advantage of the democratic countries. In the hands of a dictator, secrecy can be an effective weapon. In a democracy, the weapon will backfire. Our natural weapon is openness. It may not seem completely obvious that openness can be used to fight dictatorships. But openness will make it easier to unite the free world in the interests of safety and progress. And openness may, in the course of decades, penetrate the Iron Curtain and help us defeat the spirit of the police state.

Acceptance of Bohr's advice would reduce secrecy to its normal and historic level in a democracy. We should re-establish the situation that prevailed in this country before 1939. We should completely abandon secrecy in science, retaining secrecy only in certain operational matters. And we should maintain operational secrecy only as long as this is made necessary by world tensions.

Such a radical suggestion may not be practical at the present time. But in at least one area we can and should make rapid progress toward elimination of secrecy. The strict code of secrecy we voluntarily initiated in 1939 still prevails in the Atomic Energy Commission. Under this code, facts about nuclear explosives are born secret. All new results and discoveries are classified as secret or confidential until it is conclusively proved that there is no danger in their release. In other scientific and technical fields, the burden of proof is on the party arguing for secrecy. Non-nuclear discoveries are considered nonsecret unless it is proved that secrecy is essential. This procedure should also apply in the nuclear field. We should create and continue secret classifications only if they are absolutely necessary for our defense. Publication of scientific results should be encouraged, whenever possible, in the nuclear as well as the non-nuclear fields.

In one respect, secrecy can continue to be helpful. Although general principles can be kept secret for only a short time, technical and engineering details can be guarded with greater success. These details, in aggregate, are important and have given us reliable equipment. Rediscovery of general principles is easier than reconstruction of equipment and hardware that make general principles useful. Since the accumulation of technical and engineering details can be guarded and does result in an important advantage, we should be more careful about revealing these secrets.

In the long run, openness will serve us better than secrecy. But how far and how fast we can proceed toward openness

should depend upon a detailed study. Such a study is overdue.

This study should consider the probable advantage which we hope to derive from continued secrecy in each scientific and technical area. Only if this advantage is both substantial and highly probable should secrecy continue to apply.

The proposed study would also have to try to assess the reaction of the Soviet Union to a United States policy of nuclear openness. To expect that our complete abandonment of secrecy necessarily would lead to complete Russian openness would be recklessly naïve. There is, however, historical evidence that release of our secrets might be followed by revelation of Russian secrets. When we threw open the vast field of nuclear reactors during the 1955 Conference on the Peaceful Uses of Atomic Energy, Russia responded by opening the Iron Curtain wide enough for us to assess Soviet advances in reactor research. When we declassified Project Sherwood and revealed our efforts to control thermonuclear reactions in 1958, Russia told the world of its progress in the same field. Russia will be faced with a difficult choice whenever the United States declassifies any area of nuclear secrecy. It would have the choice of remaining silent and appearing less advanced than we, or it could follow our lead and reveal new information.

Communist countries do and must continue to interact with the rest of the world, and since Russia is not completely indifferent to world opinion, openness on our side could be expected to produce a favorable—if limited—Soviet response. However limited initially, this response might mature into complete openness under the prodding of Russian scientists who desire a free exchange of information and whose influence upon Russia's political leaders might make itself felt over the years.

Our policies of the recent past have been based largely upon an argument that seemed obvious: To reveal a secret is an act beyond recall; we must, therefore, proceed with great caution.

This caution has led us into difficulties and has profited us little. Our policies of nuclear secrecy have not significantly re-

tarded Russian advances, but they have slowed our own development and that of our allies.

A spirit of caution should also prevail during a new study of secrecy. But the caution must be applied more broadly. The danger of openness may seem great. The danger of secrecy actually may be greater.

The safety and prosperity of an interrelated world depend upon international co-operation. This co-operation must, in the end, embrace all nations. But it is urgent that full co-operation be established soon between the free and friendly countries. Secrecy stands in the way of such co-operation.

While the world is divided into opposing camps, limitations of arms are desirable. But such limitations can be enforced only in an open world. Secrecy interferes with this necessary enforcement.

We believe in the virtues of openness and freedom not only because they promote human happiness but also because they are conditions for human dignity, for effective progress, for international co-operation, and for peace with liberty. Openness would be a great source of strength in our battle for the minds and hearts of people on both sides of the Iron Curtain.

CHAPTER TWELVE:

The Not-So-Absolute Weapon

AT THE END OF WORLD WAR II, our armed power melted away. The traditional and deep-seated opposition of the American people to a big peacetime military establishment asserted itself. Even in Los Alamos I felt the powerful current of the popular feeling. My good friend, Enrico Fermi, advised me: "Come with us to Chicago; in peacetime, it will not be pleasant to stay here and work on weapons."

We all wanted peace. We believed in peace. And we were convinced that peace had come. There was a massive and irresistible demand: "Bring the boys home." There was a successful effort to cut our defense spending.

It seemed that we could demobilize and remain safe. Only the United States, after all, possessed the atomic bomb, the absolute weapon. Strategic bombing had contributed decisively to our World War II victory. The American people were conditioned to accept the doctrine of massive strategic bombing. Now we had a weapon that made strategic bombing easy and irresistible. This absolute weapon guaranteed the peace and our safety. Certainly no enemy could mobilize and supply great conventional armies while we possessed atomic bombs with which we could attack massed concentrations of troops, wipe out their arsenals, and destroy their lines of supply.

These arguments were accepted as self-evident. It was fortunate for the strength of the United States that General Curtis E. LeMay did something about the obvious and necessary task of creating a powerful nuclear air force. While most Americans relaxed in the knowledge of our nuclear monopoly, LeMay with single-minded determination built a superbly trained force that was maintained in constant readiness to strike anywhere in the world. This Strategic Air Command became the enforcing arm of the Truman Doctrine proclaiming our intention of containing Communism. A slogan later was coined by John Foster Dulles for SAC's responsibility: Massive Retaliation.

During the years immediately following Hiroshima, all this seemed to make sense. It was necessary that Communism be contained. Churchill claimed that only the atomic weapon could limit Communist expansion. We took the position that if the Soviet Union attacked any of our free-world allies, the Soviet Union would be destroyed.

This was a strong position for us to take. It was, in fact, too strong—and we backed away from it. Our atomic club was too big, and we were afraid to use it. Russia subjugated the countries of Eastern Europe and Communism triumphed in China, but there was no armed reprisal. Even during the Korean War, when we still possessed many more atomic weapons than Russia, we made it abundantly clear that we were afraid to swing our big stick.

Actually, the idea of massive retaliation is in conflict with principles that are deeply rooted in our traditions. We condemn aggression. But we also feel that we must not and cannot reply to limited aggression with unlimited destruction. It is my firm conviction that we should meet violence with appropriate resistance; but we are not justified in meeting evil with greater evil. Many say today that atomic weapons certainly are a greater evil. This I do not believe. Evil does not reside in an instrument, but rather in the manner in which the instrument is used.

But that the wholesale bombing of Russia is a greater evil than limited Soviet aggression can hardly be denied.

In a dangerous world we must be prepared for all eventualities. To build a nuclear strategic air force was a necessity. Not to develop a more moderate response to limited aggression was a mistake. To believe that atomic bombs are absolute weapons to be used only as instruments of wholesale slaughter is dangerous confusion. That this confusion should have been firmly established in so many minds was one of the consequences of Hiroshima.

The United States, confident that Russia could not produce an atomic bomb until around 1970, probably would have continued its headlong plunge toward unpreparedness had it not been for the foresight of Lewis Strauss. Months before the explosion of Russia's first atomic bomb in 1949, Strauss persuaded the government to establish regular flights of patrol planes equipped with special filters that would pick up radioactive particles from the atmosphere. Knowing the rate of radioactive decomposition of these particles, we could date their creation back to one of our atomic test explosions. In September 1949 particles were collected that could not be dated back to one of our explosions. We knew, then, that Russia had the bomb.

President Truman told the nation on September 23, 1949, about Russia's unexpected accomplishment. In the next morning's newspaper, I saw a headline: THE UNITED STATES WILL HOLD ITS ADVANTAGE. A single Russian bomb, of course, could not wipe out our advantage. But it had been predicted that Russia would not have the bomb for many years. We had been overconfident. I wondered whether, in the face of the Soviet success, we would continue in our overconfidence.

Worried and anxious, I telephoned Oppenheimer. I had been asked to give him a message during a trip to England from which I had just returned. But the real reason for my telephon-

ing was to ask the question uppermost in my mind: "What do we do now?"

Oppenheimer's answer was short and simple, and it cut off all further discussion. He said: "Keep your shirt on."

This answer worried me even more than the Russian explosion.

The day on which we heard that Russia had exploded an atomic bomb was a day like any other. It was impossible to realize that the world, suddenly, had become dangerous. Yet what had been only a future possibility now loomed as a concrete threat. Russia had the bomb. What was to have taken twenty years actually had taken only four. Atomic bombs in our possession had seemed absolute weapons. Atomic weapons on both sides now seemed to herald absolute uncertainty. The Russian achievement posed an urgent question: What should we do about the rapidly growing Soviet power?

The American reaction to this question was remarkable. It also was natural. Oppenheimer had sensed the mood of our people correctly. There was a ripple of excitement, comment, and concern. This passed, and the placid life of the United States remained undisturbed. Our response was a refusal to respond, and this was significant in leading us from our strength of 1945 to our weakness of the 1960s.

But what should we have done? Should we have taken the radical and rash way out of the problem and attacked Russia before the Soviet had a chance to bomb us? This cruel solution, a preventive war, was rejected before it was seriously considered. And no matter what the eventual consequences may be, I am convinced that in this rejection we were right.

As long as only the United States had nuclear bombs, as long as a few of our planes could devastate an offending nation, reliance on our strategic atomic bombers—if we really were will-

ing to use them—appeared logical. On September 23, 1949, the day we learned that Russia also had an atomic bomb, the concept of massive retaliation was on its way to becoming illogical nonsense. On that day we had to recognize that if we bombed Russia, we would be bombed ourselves.

As Russia advanced in the fields of nuclear weapons, airplanes, and rocketry, massive retaliation was checkmated. The United States obviously would never punish Russia for launching a small-scale invasion if our massive retaliation would provoke a nuclear attack upon us.

We were at a standoff. The diplomats called it "mutual deterrence."

In an important respect, mutual deterrence is as impractical as massive retaliation. Neither concept is workable because each pretends to draw lines where no lines can be drawn—between war and peace, between aggression and defense, between significant and insignificant acts. Each leaves us unprepared for the ambiguous acts of the Soviet government: Acts which lead to extension of Communist power, but which nevertheless are not clear-cut acts of aggression.

In the long run, mutual deterrence will fail because the policy does not consider the very different aims of the United States and the Soviet Union. Nor does it consider the methods traditionally employed by each country to achieve those aims.

The Communists have a clearly understood, openly announced, and firmly held revolutionary aim: World domination. They pursue this aim with deep conviction, with impressive zeal, with religious fervor. They have imposed great sacrifices upon the Russian people in the interest of their long-range plan to dominate the world. But that plan tells them not to take extreme chances. Russia does not enter situations which do not hold out a great probability for Russian victory. Communists move when the odds are with them. They have a word for taking unnecessary chances. It is called "adventurism," and this is one of the most serious errors a Communist can make. Soviet leaders, unwilling to take

chances that could defeat their long-range plan, are by no means careless about risking an atomic attack—not because they are necessarily concerned about the loss of human life, but because their hopes for world domination lie in the industrial complex built within Russia's borders. To lose these factories and foundries to our bombs would postpone and endanger the Communist prospects for world domination. But because they know American purposes, American methods, and American philosophies, the Communists realize they can move far and wide without risking attack. Mutual deterrence gives them the odds they need.

Our national purpose is peace, coupled with freedom and a decent livelihood for peoples throughout the world. To preserve world peace, we have adopted a policy in which I believe strongly and which I share fully: We must never strike a first blow. We are firmly convinced that it would be morally indefensible to start an atomic war. We have held to this policy. Even when the United States had a monopoly of nuclear weapons, we did not seriously consider using them although Communism used the force of arms to suppress freedom in Eastern Europe and to conquer China.

The policies of both massive retaliation and mutual deterrence carry the threat that the United States will fight if our allies are attacked. This is basically inconsistent with convictions which are strongly held by many Americans. It also is exceedingly dangerous. This threat, carried out, would expand a localized conflict into a world-wide nuclear war. I do not believe that the United States should unleash an all-out atomic attack for any lesser reason than to return a full-scale attack made upon us.

The crises of threat and counterthreat involved in mutual deterrence strongly favor Russia. No matter how often the United States sends strongly worded diplomatic notes, Russia knows that we will not launch the first nuclear attack. This leaves the field of ambiguous aggression open to them. Russia can support Communist revolutionary movements in the Congo or Cuba secure

in the knowledge that the United States will not retaliate with nuclear bombs dropped on Russia. Soviet leaders are just as secure when they taunt us, when they insult our President and our nation, when they subject us to nuclear blackmail by threatening to bomb our country. They know we will not attack first. Ambiguous aggression may not appear to conquer the world for Russia in a hurry; but step by step, nation by nation, convert by convert, it will conquer the world eventually. And this our policy of mutual deterrence does not deter.

If massive retaliation and mutual deterrence are unworkable, what can we do? Many people believe this complex question has an easy and wonderful answer: The main threat is posed by nuclear arms. Let the world disarm, and the threat will disappear. Gradually this notion has become gospel. But disarmament, so far, has served us no better than our reliance on nuclear arms. Hopes of disarmament have persuaded us to lower our guard while conceding to the Russians the opportunity to gain strength with secret preparations for conflict.

This much is evident: Appeasement on our side and confident expansion on the side of the Communists have been the dominant themes of the postwar years. This situation must be changed; it can be changed. We must adopt methods in which we can have confidence and with which we can accomplish our main purpose: Stable, peaceful co-operation between nations.

An all-out nuclear war with Russia can be avoided. But I do not believe that this can be achieved by the threat of massive retaliation or by mutual deterrence. I do not believe that we can find a simple solution for a critical, complex problem.

Absolute weapons do not exist. But nuclear weapons are by far the most powerful instruments at the present time. It would

be foolhardy for the United States to conduct its military planning as if nuclear weapons did not exist.

These four points, to be discussed in following chapters, are necessary for a strong United States position in the nuclear age:

1. We must have an adequate passive defense. We must anticipate nuclear attack and be prepared to survive it. A nuclear attack on the United States would be horrible beyond imagination, but we must imagine it. We must, in fact, plan against it. An unprepared nation invites attack. We must, therefore, prepare for an attack. Properly prepared, we can survive a nuclear attack.

2. Having survived an attack launched against us, we must be able to strike the second blow. The United States has started to build up a second-strike force, a strong nuclear force capable of immediately returning any attack made upon our nation. This would not be massive retaliation, which calls upon the United States to return any attack made upon any ally. Our second-strike force would be mounted to return an all-out assault only if our own nation or territories that share our loyalties and institutions were attacked. In making certain that we could absorb and return an all-out nuclear attack, we would attain a major but limited objective: Our survival as an organized society with an organized industrial complex and an advancing civilization. If we were properly prepared, Russia, of course, would know that we could survive an attack made directly upon our nation and would know we were capable of counterattack. The Soviet Union, knowing these things, would never attack the United States directly.

3. We must prepare for limited warfare—limited in scope, limited in area, limited in objectives, but not limited in weapons. A localized, limited nuclear war will be the answer whenever the Russian method of ambiguous aggression degenerates to an outright attack against our allies. It will be the alternative to a disastrous, all-out, world-wide nuclear war. To prepare for a limited war, we must develop new kinds of international di-

plomacy, new theories of battle tactics, new varieties of nuclear weapons, new kinds of fighting men.

4. We must realize that passive and active preparedness will buy us nothing but time. We must use this time to establish a lawful and prosperous community of nations to ensure peace. Our ultimate goal can be nothing less than world government based upon the principles of freedom and democracy. Of our four points, this last is the most difficult.

I believe that each of these four points is indispensable to our survival. Because we refuse to think and plan, our preparedness now is so lax that we could not survive an atomic attack upon our own country. There would be little benefit in surviving if we were not prepared to fight back with a second-strike force. We cannot afford to let Communism engulf the rest of the world either by ambiguous aggression or by attack upon our allies, leaving the United States an island in an unfriendly Red sea; we must be prepared to fight limited nuclear wars. And, although the difficulties almost seem insurmountable, we must strive for the ultimate objective of world peace through establishment of a world authority that wields moral and physical force to safeguard peace with freedom.

When we are faced with a great and terrifying development, we are apt to imagine that none could be greater. We have heard much of the absolute threat of absolute destruction by an absolute weapon. The atomic bomb, with the destructive load of a thousand blockbusters, at first was the absolute weapon. Then the hydrogen bomb, carrying the power of a thousand atomic bombs, became the absolute weapon. Now we know about the intercontinental ballistics missile, which can deliver its load of hydrogen bombs anywhere on earth in 20 minutes, and this seems to be the absolute among absolutes.

Actually, an absolute weapon does not exist. We live in an Alice-in-Wonderland world. We must run fast just to stay in the

same place. If we stop, we are falling behind. A method of destroying ICBMs and rockets, a discriminating tactical nuclear weapons system, an adequate network of bomb shelters could upset any calculation based on absolutes.

The only absolute likely to defeat us is fear, the persuasion that we cannot escape. But even fear can be defeated by rational, planned action.

CHAPTER THIRTEEN:

Off the Beach

AN ENGLISH NOVELIST, several years ago, wrote a book that had a deep and frightening influence upon the minds of men. The author, Nevil Shute, had written many vivid stories about the problems of our age—an age that has more questions than answers. This particular novel was built around an old theme: The end of the world and the ways in which men would face universal annihilation.

Considered coldly and factually, Shute's story has no relation to any possible future event. The catastrophe described in the book was caused by a world-wide conflict fought with cobalt bombs. These bombs do not exist. They would have no military usefulness. They would do their greatest damage not on the spot of a target, but around the globe; not immediately, but after the passage of years. The damage described in Shute's book could not have been caused by the bombs exploded during the war which, according to the narrative, results in the end of man. The cobalt bomb is not the invention of an evil warmonger. It is the product of the imagination of high-minded people who want to use this specter to frighten us into the heaven of peace.

In many other ways, Shute disregarded the real facts of life. Radioactive contamination is treated as a contagion. An exposed person—who actually could be decontaminated—is left to perish

Communists know they never will need to strike us in self-defense. But as long as the United States is unprepared to absorb and survive an all-out attack, the Communists have a temptation that might prove irresistible: A quick and easy nuclear victory over the nation most effectively thwarting their aspirations for world domination. If we are prepared for an all-out nuclear war, if we know we can survive the most vicious and widespread nuclear attack, if we guarantee our ability to rebuild our industrial complex after an attack, then the only valid reasons for a Communist attack upon our nation will have been removed. If we prepare, this disaster will never come.

A civilian defense system protecting people all across our nation obviously will be a tremendous undertaking, but it must be undertaken. The task looms larger because so little has been done. We literally must start from scratch, because this peaceful, nonaggressive guarantor of peace has been neglected for so long. The United States today has no comprehensive plan for civil defense, let alone adequate structures for civil defense. But at least the general outlines are clear, and we know that a plan can be written and a civilian defense complex can be built.

What must be done?

An adequate defense demands that we have early warning of attack, shelters, organization, clean-up equipment, and a plan for reconstruction.

Before we can begin to save ourselves from attack, we must know that an attack is coming. We must have as much warning as possible because our chances of survival would be measured in minutes. A rocket's travel time from a launching pad in Russia to a target in the United States would be only about twenty minutes. Fired from a Russian submarine, a rocket could strike a target in the United States in even less time. Without a fast and accurate warning system, an enemy rocket could obliterate

a large American city and its unsuspecting residents even before we knew we were being attacked.

The United States, fortunately, has established a complex and effective warning system. We have developed and are refining ways of detecting launchings from any part of the world as soon as the rockets rise into the air. Even more warning of an attack would save millions of lives, and more warning might be possible. The urgent need for the earliest possible warning of attack is one reason why observations of the whole world and all of the earth's activities—an "Open Sky" inspection from airplanes or satellites—have become so vital to our security. We have not yet attained an "Open Sky" inspection, but we have achieved a warning system that will tell us we are being attacked the moment rockets start to fly. So we can depend upon at least a little warning, and the short time we might have to save ourselves probably will not be shortened appreciably in the future because it would be exceedingly expensive to make rockets fly faster.

One of the most essential steps we must take is the establishment of reliable communications that would survive any attack. These communications should be used to warn our people of impending danger and to direct our essential post-attack efforts to save human lives and to recover from the blow.

In a sudden nuclear attack upon our nation, there can be no doubt that millions of Americans would die. But even the brief warning we would have if such an attack came tomorrow would be enough to save perhaps ninety per cent of our people—if they knew what to do in case of attack and had the means to protect themselves. The present warning system would alert our military establishment, but it would not save the majority of our people because they are uninformed about civilian defense methods and unprepared for survival. If we continue to neglect civilian defense, a nuclear attack on the United States could kill well over 100 million people. And the fate of the survivors would be no better than that of those who had perished.

In order to ensure ourselves against the horrors of such an attack by being thoroughly prepared for it, our people must be sheltered, organized, and educated.

Our most urgent need is a nationwide system of public and private shelters. To protect people in all sections of our nation from the expected and probable, a national program of shelter construction should be given at least as high a priority as any other project in our over-all defense effort. Detailed studies and plans are necessary. People in various sections of our nation will require different degrees of shelter protection.

Perhaps two thirds of our people live in the uncongested areas of our nation. Far from prime targets, people in these areas can be protected more easily. They probably would not be subjected to the blast of a direct nuclear attack. They might, however, be endangered by radioactive fallout of a very great intensity; after an attack, clouds of radioactive poisons could be expected to sweep over large portions of our country. They might also be exposed to conflagrations due to high-altitude explosions of the biggest nuclear weapons or carried to their neighborhoods by the winds.

Survival of people outside our cities would be favored by some circumstances: Time would be required for fallout to float downwind from the actual point of attack. In addition to the initial twenty-minute warning of an impending attack, these people could count on another half-hour, one hour, or even more time after attack before they would be endangered by fallout. This would give most residents time to protect themselves.

Effects of fallout often can be decreased simply by going indoors or taking shelter in a conventional basement. Protection almost always is sufficient in a fallout shelter built with thick but not necessarily strong walls and equipped with a filtered air system or properly designed ventilation. A reasonable measure of protection, in some rural areas, can be offered by simple shelters for individual families. These might resemble the storm cellars already built as tornado protection by many families in

our Central Plains states. Or rural families could build simple and adequate shelters by piling sandbags around the walls of a small building. The best protection, however, would be in community shelters. All the people in a small town probably would have time to reach a community shelter specifically designed to protect against fallout. Community shelters would offer greater protection at a lower total cost than a number of individual family shelters. And, because fallout might continue to be dangerous for some time, it would be best for entire communities to plan together.

Even though blast would not be a danger in these areas, fire damage is a real threat. This argues for construction of shelters that could survive a conflagration. It would be a further advantage if the shelters contained their own air supply. In many cases, it would be simpler to build the shelter in a location that would not easily be reached by fire.

In cities and prime target areas, the problem of providing adequate protection is much more difficult. People in our urban and suburban areas, like those in our rural sections, must be protected against fallout and radiation. But the people in and near our cities also require protection against nuclear blast and the even greater danger following the blast: Fire.

Civilian defense shelters in metropolitan areas and near important targets must be shock resistant. They should be surrounded with loose material that would dissipate the shock of a nuclear blast, and the shelters themselves should be rigid enough to withstand the shock penetrating the surrounding cushion. Dirt is an excellent shock cushion, and the most effective shelters will be built underground. These need not be deep. People in well-constructed shelters only ten to twenty feet below ground would have reasonable protection from a thermonuclear bomb exploding only one mile away. In shelters 100 to 200 feet below the ground's surface, there would be greater safety. In a thermonuclear attack we cannot ask for complete assurances. But we can and should save most people.

Effective protection against fallout, shock waves, and fire produced by a nuclear attack upon a metropolitan area also can be provided above ground. Our skyscrapers could be built around a windowless, rigid core of concrete made sturdy enough to withstand a blast's shock after it had been dissipated by the offices and corridors in the building's outer structure. These concrete cores would offer substantial protection. And they would be readily accessible to people in the most congested parts of our metropolitan areas.

People in cities will have only a brief warning of an impending attack. Therefore, every worker and every resident of every large city in our nation should be able to reach protection in a five-minute walk. Sturdy shelters should be built to accommodate everyone living or working within a quarter-mile radius of the shelter site.

It is important to realize that not all of the dangerous effects would be generated by each exploding nuclear bomb. Conflagrations over the widest areas could be kindled by very high altitude explosions which create no fallout hazard and which may not cause great shock damage. Air bursts of moderate height produce the widest damage through air shock, but would not damage well-constructed underground shelters and would not be likely to create concentrated fallout. The explosion producing really dangerous fallout would be a ground burst. This explosion also would cause ground shock and could damage underground shelters in the vicinty. But the air blast and the fires resulting from such explosions would cover smaller areas. In constructing shelters, it is important to assess which of these possibilities is the most likely.

Even in target areas, mass shelters can be built offering a real chance of survival for $200 a person. On a national scale, an adequate shelter construction program would cost about twenty billion dollars. This sounds prohibitive. It is not. It is about half of our annual defense budget, and as a necessary insurance

against nuclear attack, the cost of adequate shelter protection is cheap.

The price of survival actually might be considerably less than twenty billion dollars because there is no reason for shelters to remain unused except in case of attack. Shelters can be built for more than one purpose. They can be designed and equipped to provide protection if protection is needed, but they also can have other functions.

It would be particularly important to build adequate shelters in our schools. It might even be advisable to contemplate building the schools themselves, with modern lighting and air conditioning, underground. On the surface above the underground school, children could have a really adequate outdoor playground. The underground school, of course, would be constructed and equipped as a mass shelter. There would be no problem of getting the children from classroom to shelter after an alert, and we would be reassured by the fact that our children were given the greatest safety. The cost of this shelter would be reduced by the amount of money that would have been spent on a conventional school.

Dozens of other kinds of buildings, similarly, could be constructed underground and serve dual purposes as housing for normal functions and as community shelters. We could make mass shelters of underground theaters and auditoriums, supermarkets, parking garages, warehouses, hospitals, or any other kind of structure that will accommodate many people. Concrete cores of office buildings, likewise, could be more than shelters. They could be garages, easing congestion in the hearts of our large cities. Garage cores have been built in office buildings in our country, and they have been found to be practical and convenient. Office tenants of the Redick Tower in Omaha, Nebraska, and the Cafritz Building in Washington, D.C., can drive into their buildings and park on the same floor occupied by their offices. These are examples of garage cores; to be shelter cores as well, they need only more sturdy construction. Our cities are the great

American repositories of culture. In our cities are the large museums, the most valuable collections of paintings and sculptures, the great libraries of books, the best examples of our cultural heritage. Many of these same cities would be targets for a nuclear attack, and such an attack probably would destroy these cultural achievements of man. I would propose that our museums and libraries be built underground and equipped as community shelters. In case of attack, such shelters would save many lives while preserving some of the chief reasons for living.

Multipurpose shelters may reduce the cost of this phase of civilian defense. But even at a reduced cost, the question must be asked: Who will pay for it?

I don't know the answer to this question. The main concern is that an answer be found soon. The full bill, certainly, would not come due in any one year. Three to four years probably would be required to build the kind of national shelter network we so urgently need. The costs might be paid by the federal, state, or local governments—or shared by all three. It surely would be improper for any new federal or local government buildings—post offices, schools, courthouses, office buildings—to be built without shelters. Much can be done to encourage private individuals and businesses to build shelters. The builders of new warehouses, bowling alleys, theaters, parking garages, or supermarkets might find it to their advantage to build underground if the government offered appropriate subsidies. Real-estate tax exemptions might prove strong incentives for shelter construction. Shelter needs differ from place to place; so while all shelters should be a part of a national plan, details could be settled advantageously on local levels—by states, counties, cities, private individuals, and companies.

If we are attacked, heavy radioactive contamination of the ground and atmosphere may force people to remain in their shelters for days and possibly for weeks. Each shelter should be stocked with enough food, water, and medical supplies to meet the needs of the shelter's occupants for two weeks. It would be a

very great help to have a filter system to remove radioactivity from air brought in from the outside, to have enough oxygen to provide an independent air supply for several hours—long enough to last through the fire storm—and to have chemicals which absorb the carbon dioxide exhaled by the occupants. Each shelter should also be equipped with an independent source of power to operate the air filter and to maintain radio communications with other shelters and with civilian defense headquarters. And, finally, each shelter should have a store of water and chemicals for hygiene; urban shelters should be constructed with several exits and stocked with dig-out equipment so their occupants would not be trapped by an explosion's debris.

A few days after an attack, people as a rule will be able to emerge from their shelters for limited times in limited places. Or they may have to remain in their shelters as long as two weeks. Shelters may have to serve as living quarters for months after an attack. Most buildings would be destroyed by an attack, and in many regions of our nation some radiation would remain, and time spent in these areas would have to be limited.

Shelters and equipment will not be enough for survival. We must have organization. All of our people should participate in a civilian defense training program. This is of the greatest importance. Every citizen must understand and practice civilian defense.

Either a limited or an all-out nuclear war would require the services of only highly trained, professional soldiers. General mobilization of manpower would be ineffective, unnecessary, and impossible. Instead of being available for conscription into the Armed Forces, our people should be drafted into civilian defense organizations. All should be trained in civilian defense fundamentals: All must know how and where to seek shelter. Once inside a shelter, our people must know how to organize for the safety of the group. They must be trained to follow the direc-

tions of a shelter leader and a shelter doctor. They must be trained to operate communications and air-filtering equipment. Before they can hope to emerge safely from the shelter, they must know how to measure radioactive contamination, and they must know how to wash it away.

An all-out nuclear attack upon our country would be terrible indeed. I do not believe it will come. But if it should come—and if we are prepared to shelter ourselves from its effects, if we are equipped and organized for survival—even an all-out nuclear attack would be no worse than some of the terrible events of past wars.

Radioactive contamination does not stay in the air over the target of a nuclear attack. It is blown away by the wind. It will pass over a given place in half an hour. Within three days of a nuclear attack upon the United States, airborne radioactivity would be blown away from our entire nation. But this is of little comfort because radioactive poisons, in addition to being blown away, can settle onto the ground.

The amount of radioactivity on the ground after an attack would depend upon the altitude at which the bombs were exploded and upon other factors. The post-attack fire storm, by creating an ascending air mass of considerable velocity, might help to keep the ground surface of a target area relatively clean of radioactivity.

But in planning our defense, we must assume that a nuclear attack would leave a good deal of radioactivity on the ground. A thermonuclear explosion would leave a city in rubble, and all or much of that rubble might be radioactive.

In urban areas this radioactive rubble could pose an additional threat to the survival of people who had been sheltered against the initial blast and the terrifying fire storm. In two weeks the radioactivity would have decayed to a level low enough to allow people to come out of their shelters and, in appropriate loca-

tions, resume work above ground. In the exceptional cases of very high radioactivity, bulldozers could be brought in and used to clean up essential areas or escape routes by pushing debris and topsoil aside. Radiation, in any case, will decay a little faster than the inverse proportion to the time passed. After one day, only three per cent as much radiation will remain on the ground as was there an hour after the explosion. After a week, the amount of radiation on the ground will be ten times less. After two months, the activity will be ten times less again.

We can save most of our people, and the survivors soon could turn to the problems of the new days to come. They must know what to do and how to do it.

While the majority of our people can be saved from an all-out nuclear assault, we cannot hope to save most of our goods or the factories that manufacture our goods. In an all-out attack, our industrial complex probably would be effectively destroyed. It can be rebuilt if we provide for its reconstruction. But it cannot be rebuilt and survivors of a nuclear attack will be without support and may face starvation if they have to start the task of reconstruction from scratch with no better tools than their bare fingers.

Much of the strength of our industrial society, fortunately, is not in our industrial plant. Our factories are expendable. Our strength is in our know-how and in our organization. Our gross national product, the value of everything manufactured or mined or produced in the United States, now is more than 500 billion dollars a year. But the total value of everything that exists in the country—all the houses, clothes, food, factories, minerals, farms, services, cars, everything that can be bought or sold—is only about 1500 billion dollars. Everything we have, in other words, could be produced by our present industrial complex in only about three years. This means our present standard of living is extremely high and our rate of consumption is prodigious. This

also means that survivors of an all-out nuclear attack, given food and a bare minimum of essential tools, could rebuild our industrial complex in a very short time. Even if our industrial plant were totally destroyed in an all-out attack, properly fed and equipped survivors living in austerity and working with complete dedication could rebuild our industrial plant to its pre-attack productive capacity within five years.

Just as we need to plan the construction of shelters to protect our people, we should begin a searching and exhaustive study of the things those people would need to survive after an attack and to rebuild our economy. We should plan and provide for our economic survival as well as for our personal survival. A thorough study must precede a complete plan for economic survival, but some potential needs already are obvious.

Survivors would need food. Shelters, hopefully, would be stocked with enough food to sustain people for two weeks after an all-out attack. This would feed them during their confinement in the shelters, but more food must be easily available after they emerge. Fortunately, we have a solution at hand. We have a national treasure that is considered an embarrassing political liability, but it could be converted into a great asset: Our agricultural surpluses.

The government today is storing enough surplus food to sustain the survivors of an all-out nuclear attack for perhaps two years. But it is not distributed so as to be available in all parts of the nation. It should be. Our surplus foods should be safely stored and located throughout the nation, making supplies of food available to all survivors. Wheat and other raw foodstuffs, furthermore, should be partially processed or stored with processing equipment so that survivors would not starve next to a filled granary.

Survivors would need tools and machines. These needs, likewise, can be met rather easily. Our government has moth-balled billions of dollars worth of equipment used during World War II and the Korean War, and we have stockpiled machine tools and

strategic raw materials. Most of this storehouse of equipment, tools, and materials would be useless during a nuclear war, but it would be most useful for survival after a nuclear war. Our mothballed fleets, our desert dumps of outdated aircraft, our entire inventory of military surpluses and stockpiles should be carefully studied. Tools and parts and machines and materials that might be put to work after a nuclear attack should be distributed over the nation for safe storage.

Private industries should be given tax write-offs as an incentive to save equipment from the junk heap today for survival tomorrow. American industries are making steady advances in engineering and technology. Machines are being discarded and replaced as manufacturing methods are modernized. These workable machines should be stockpiled rather than junked.

We could store our old machines in simple, weatherproof, and widely dispersed structures. Fallout would not harm these machines, nor would moderate blast pressures destroy them. When needed, they would be ready for use. Equipment considered obsolete today would be invaluable to the survivors of a nuclear war.

Survivors would need transportation. Safely and speedily, they would have to be able to get to underground supply dumps of food, machines, and raw materials. Our systems of roads and national highways probably would not be destroyed by an all-out attack. But key links in our highway system probably would be knocked out. Our economic reconstruction would be accelerated if destroyed links in the transportation system could be repaired speedily. Repair equipment and materials should be safely stored near anticipated trouble spots. Materials necessary for the building of a simple pontoon bridge, for example, should be stored now near bridges likely to be destroyed in a nuclear attack. Our refineries and our stores of gasoline may be lost. But we could encourage each filling station outside our cities to store gasoline in a reasonably safe place now. If all these stations would carry

ten times their present stocks of gasoline, a small but valuable contribution to our recovery would have been made.

Survivors would need energy. Reconstruction of a factory would be of little use if there were no power available for its operation. Revival of our industrial capacity would be agonizingly slow if our people had to depend upon water wheels and other primitive power sources. Our best guarantee of an efficient and effective postwar source of energy would be the construction, now, of underground nuclear reactors. Most nuclear reactors today are built above ground, and must be enclosed in a gas-tight sphere for absolute protection against an accident that would release radioactivity. This sphere is expensive. Construction of reactors underground, where no sphere would be needed, would be not much more expensive and might be even cheaper than aboveground construction.

Many individual parts of our recovery plan must be worked out and fitted together. There can be no doubt that industrial production will eventually recover after a nuclear attack. But if we prepare properly, the recovery could be fast.

Survivors, above all, would need organization. They would emerge from their shelters into a kind of world man has never known. Millions would be dead. The standard of living, highest in history only two weeks before, would be near zero. Things our people long have considered as necessities suddenly would have become the hoped-for luxuries of the future. Life would be bleak and cheerless, and life's prospect would be the necessity of rebuilding our productive capacity before stored supplies of food were dissipated.

In such a world, people would have to live and work according to a plan. Teamwork would be essential. The pressing goal and aim of our people would be group effort and survival.

If we wait until we are attacked to plan our postwar organization, there is a very real danger that we might lose our individual

liberties and freedoms permanently. The postwar society will need rigid organization for its own survival, and rigid organization usually leads to tyranny.

If, on the other hand, we plan a postwar organization before we are attacked, our liberties can survive.

When young men and women join the Armed Forces today, they lose many of their rights as individuals. They must subject themselves to a rigid discipline. But they know that this discipline is only temporary. They know that when they leave the Armed Forces, their full rights will be restored.

It is this kind of postwar organization we must plan now. We must anticipate a strict state of emergency, but we must limit it to the time of the emergency. We must understand that during the critical five years after attack, when the needs of the group and of the nation are paramount, the individual will have to make great sacrifices. But we must guarantee that after the emergency has passed, after our economy has been rebuilt, our way of life, our right to the pursuit of happiness, will be restored.

We should define the necessary emergency measures while we can do so rationally and in freedom. In this way, we can be sure that the emergency measures will be properly limited.

Our almost total lack of civil defense is the weakest link in our national security, and so it is the greatest danger to peace. In an area where so much needs to be done and so much should be done, we have done practically nothing. Russia, on the other hand, has done much.

Our Office of Civil and Defense Mobilization says: "Official Soviet interest in new shelter construction has been apparent since about 1950. New building construction in some Soviet cities is known to include shelter as a matter of routine. . . . The impression is gathered that the inclusion of protective construction features in new buildings is a standard practice in many centers of population and industry, and that basement shelter of some

kind already is available to an important segment of the population of urban areas of the USSR." The average adult Russian is given about sixty-four hours of civil defense training each year. The Soviet government has distributed plans for "hasty shelters" that can be erected to protect Russian families against fallout within twenty-four hours after warning of an attack. An estimated fifty million Russians participate in some phase of the Soviet Union's civil defense program; the United States has only 2000 professional civilian defense workers, and private citizens now are given almost no training.

Even though Russia is struggling to build her economy, even though it is more painful for the Soviet Union to spend money for civilian defense, Russia has spent much more than the United States on shelters and on an effective civilian defense organization. Unless we change, unless we spend vastly greater amounts, it is likely that Russia would survive an all-out nuclear war and we would not.

It is useful to compare the economies of Russia and the United States. We are fat and Russia is lean. In a conflict, to be lean is an advantage. But our wealth can enable us to put things aside for a dreadful rainy day, helping to ensure that we will never meet the lean ones in conflict. To stockpile food and machinery for survival is incomparably easier for us than it is for Russia. We have surpluses. Russia does not.

Judicious stockpiling in the United States during the next few years would make it completely clear to the Communist nations that we could recover faster and more effectively after an all-out nuclear war than could Russia.

I believe that the Soviet Union is not anxious to participate in an all-out nuclear war for an important economic reason. The Russian people have made tremendous sacrifices to build up the Soviet industrial plant. Russians are proud of their new factories and of their new products, and they do not want to lose them. Those factories and those products are important Russian assets in their fight for world domination. With adequate civil defense

preparation and organization, we can assure ourselves and the world that after an all-out war the United States would be able to re-establish economic strength sooner than Russia—and so the United States would remain by far the strongest nation in the world. Thus every trace of motivation for Communist attack upon our nation would vanish.

Fortunately, our civilian defense effort is no longer completely paralyzed by fear and despair. On May 9, 1961, President Kennedy proposed to triple the budget. In New York State, after years of careful preparation, a vigorous program was undertaken by Governor Rockefeller. Throughout the nation, common sense and the will to survive have begun to reassert themselves. We are moving off the beach.

Even in case we are attacked, we can survive if we are determined and translate our determination into action. The first and basic objective of any defense is survival. If our individual and national survival is assured, we can proceed with confidence to build all the other bulwarks that are needed to maintain peace.

Development of lightweight, mobile retaliatory missiles would improve our chances of defense because such targets could be maintained as moving targets. Additional retaliatory bombs should be located in many solidly built and well-defended bases. It may be impossible to shoot down all approaching missiles. But if a missile has to make a precise hit on a missile base to be effective, there is a real chance for an anti-missile defense protecting a sharply defined point. Much thought and work will have to go into this second-strike force, but better nuclear explosives are the beginning and the end of every improvement. Smaller explosives will make our missiles more mobile and easier to defend. Better explosives will make the hard task of point-defense against missiles somewhat easier.

The plan to launch our counterattack only after we have been bombed decreases the chances of accidental war. But a second-strike force requires many retaliatory missiles which must be kept in constant readiness. This may seem to increase the chances of a tragic mistake. Actually, a great deal of thought has been given to devices which will eliminate the possibility that the human error or aberration of a single person in charge of a retaliatory missile could unleash a war. Using past accomplishments and future progress, we can make absolutely sure that our government has a restraining power and that as long as our government is functioning, only the most responsible persons to whom we have entrusted our fate can order a counterattack. Our strength would give these men the assurance that they never need act in haste.

On the other hand, we need not worry that the Communists can defeat us by knocking out our government and eliminating those empowered to order a counterattack. The safeguards against an unauthorized launching of our second-strike force can be so arranged that as soon as our government ceases to function, the safeguard also ceases to be in effect. With the country in

flames, the dispersed units would be free to do their duty and strike back.

The problem of creating a second-strike force that can *never* strike first but that can *surely* strike in retaliation is not easily solved. But it can be solved.

There remains a question that is most disturbing: What should we do if one of our closest friends were subjected to an all-out bombardment? What should be our reaction if England or Canada were attacked?

One possible answer would be our declaration of a limited war. We must try to limit the territory and the aims of such a war, and we must do all we can to help our ally without allowing the conflict to become world-wide. How this might be done will be discussed in the next chapter.

This answer may be logical. But it will not satisfy everyone. It does not satisfy me. Unfortunately, I could accept only one alternative. And this alternative, while probably the right one, is most difficult.

If two countries are so closely tied together that nuclear bombardment of one necessarily will lead to nuclear bombardment of the other, then these two countries in reality are not two but one. In this case, the policies of the two countries must be shaped by common participation and consent. Instead of two separate loyalties, there should be a single loyalty. The governments of the two countries in many respects may continue to function separately. But in the most important areas, in the questions concerning survival, there can be but a single government for the two countries. In that case, effectively and morally, an attack on one would be considered and announced as an attack on both. A union would in fact be created, and the ambiguous situation of an attack on an ally would be replaced by the straightforward demands of self-defense.

The stability of the world, in the long run, demands a suprana-

tional authority. It can be argued—indeed, it has been argued—that the time has come to establish a single government responsible for the survival of England and the United States right now. It might be possible and necessary to establish an even more inclusive union at the present time. My own belief is that such a step would be an early recognition of an inevitable development and would greatly increase the chances of continued peace.

The choices that are before us are not easy, and we cannot make progress toward a stable world without sacrifices. But this much is clear: Our position will be more firm, secure, and right if we establish a strong second-strike force and if we develop our ability to fight a limited war in order to defend our allies.

CHAPTER FIFTEEN:

Limited Warfare

THE KOREAN WAR TAUGHT the United States two great and valuable lessons. We would do well to remember them.

Conditioned by two global conflicts, the American people in 1950 had a big-war mentality. They could not conceive of a conflict limited both in political aims and in geographical area. The opinion prevailed that any kind of war almost automatically would become a world war. Korea, politely termed a "police action," was a practical and effective reminder that we could participate in a limited war without becoming embroiled in a world-wide catastrophe.

Korea taught the American people another and more bitter lesson, one that military leaders always had accepted as axiomatic: We should, if possible, avoid fighting on the enemy's terms. The enemy in Korea had tremendous advantages. He could select the place for war; he could set the time for attack; he could effectively dictate the scale and the method of war. Fighting an enemy with these considerable advantages, the American people learned that we cannot allow future enemies to dictate the terms of future wars. It was a difficult lesson to learn. It cost three years of hard fighting and 33,629 American lives. Still, it is not completely clear that we have learned this lesson.

The Korean War demonstrated these two important lessons, but it also implanted a grave misconception in the minds of most

Americans. At a time when we had a clear-cut atomic advantage over the enemy, President Truman stubbornly and steadfastly refused to authorize the use of nuclear weapons against Communist forces in Korea. Military men, anxious to use their most effective weapons to shorten the war, were unable to persuade the President who had taken full responsibility for the surprise nuclear devastation of Hiroshima and Nagasaki. He was adamant, and nuclear weapons were not used in Korea. Use of atomic weapons at that time, indeed, might have turned millions of Asians against us. But Truman's stand gave birth to an idea which has become generally accepted but which is, nevertheless, invalid: If neither side uses nuclear weapons, there is real hope of keeping the scope of a war limited; but the moment either side does employ nuclear weapons, nothing can prevent expansion of a limited war into an all-out nuclear catastrophe on a world-wide scale.

Korea established two precedents and proved two principles of limited warfare. We learned, in Korea, that wars can be limited in area: Rightly or wrongly, the area of fighting in Korea was limited to one side of the Yalu River. We learned that wars can be limited in their political aims: The fighting, clearly, was for Korea and nothing else. These precedents both are valid. But Korea also gave rise to the popular idea that a war can be limited only if it is non-nuclear.

This last idea is not only invalid but dangerous. The misconception that *any* use of nuclear weapons would expand a conflict and inexorably trigger an all-out global war has been accepted as an unquestioned fact by many of our highest government officials and has been a prime consideration in our international conduct and military planning. As a result, we have concentrated on preparations for a kind of war that I doubt will ever be fought again. We have continued to draft thousands of young men and have taught them to stand at attention and march eyes-right. We have continued to build and man aircraft carriers and other huge surface ships. We have spent billions of dollars on

conventional arms for a conventional force, acting on the assumption that wars in the future will be fought like wars in the past. History differs, and tells us that the ways of fighting wars change. But this lesson of history has been largely ignored, and we have continued preparations for a non-nuclear conflict at the expense of the development of the kinds of effective nuclear weapons and other military methods that surely will be employed in future wars.

We must recognize that Russia inevitably would have three overwhelming advantages in a war fought by conventional, historical means. The massive, disciplined manpower of the Communist countries has given the Soviet Union far and away the most powerful peacetime army in the history of the world. Russia is in a central, strategic location—near the countries in which a limited, conventional war would most likely be fought. And, finally, Russia is not unwilling to take the initiative.

The United States is strictly circumscribed by traditional and historical principles. Our people have strong feelings against aggression. Russia is not so circumscribed nor so hampered. On the contrary, Russia is opportunistic and is capable of grasping the initiative whenever a nation's internal politics or external defenses seem to assure Russian success. Combined with the Soviet's strategic location, this willingness to take the initiative would give Russia a tremendous advantage in a conventional war limited in scope to one of the nations on the periphery of the Communist empire. Before we could get our conventional forces to the front in sufficient numbers to wage a non-nuclear war, the Communist armies would be firmly entrenched.

Two imaginary future wars might demonstrate our alternatives. The outcomes are quite different, but they are not difficult to imagine because one or the other is being written by our military planners today. One outcome would be a death-blow to American prestige, and would lead to the eventual extinction of our

national government. The other outcome would enhance America's position of world leadership, guarantee our existence, and preserve our freedoms. We will consider the two distinct possibilities as histories:

A CONCISE HISTORY OF THE WAR OF BRAVADO

The country of Bravado was a small but strategically located nation adjoining Communist bloc countries near the Scrobean Sea. The democratic government of Bravado outlawed the Communist Party, but the Bravadonian Communists continued to function underground and attracted some support among student organizations.

On September 13, 1965, these Communists, in an internal uprising, usurped the established government and precipitated the War of Bravado, the shortest war in the world's history. The Communist uprising was well co-ordinated. Various Communist units, carrying small arms made in Russia, simultaneously took control of Government House in Scrobea, the nation's capital, and captured the city's two newspapers and three radio stations. Loyalist officials found just enough time, before fleeing Scrobea, to send an urgent message to Bravado's ambassador in Washington, X. G. Strunk.

Strunk won an immediate audience with the President of the United States. The mutual defense treaty between Bravado and the United States was invoked. The President, acting as Commander in Chief of the Armed Forces, ordered American troop transports and aircraft carriers to sea, then placed our Air Force bases overseas on an alert for a possible attack against the Bravadonian Communists. While our warships were steaming toward Bravado, the President called a special emergency session of Congress. He wanted the legislators to issue a Declaration of War before actual fighting began. As congressmen converged on the nation's capital for the historic session, Air Force reconnaissance planes roared from the runways of U.S. bases in England and

flew toward Bravado with rather ambiguous instructions to "report" on the "strength" of "Communist forces."

Three hours after Ambassador Strunk had called on the President to ask for U.S. aid, Radio Scrobea said that a large force of Russian paratroopers had landed in the capital of Bravado after a short flight from Communist territory. Within minutes after this report was picked up by U.S. radio monitors on Long Island, the Kremlin announced through regular diplomatic channels that Bravado was a Russian protectorate. The Soviet government recognized the new government of Bravado and warned all nations that it would be defended against any aggression.

Five hours after the President had acted on Ambassador Strunk's request for aid, the Air Force reported to the Pentagon that communications with U.S. reconnaissance flights had failed. The new Bravado government subsequently revealed, over Radio Scrobea, that the United States reconnaissance planes had been shot down as aggressors and that five surviving American pilots had confessed that they had been ordered to fly over Bravado as spies.

Congress had not yet convened in Washington. On the heels of Radio Scrobea's spy charges, the Kremlin issued Russia's famous White Paper. The White Paper formally accused the President of the United States of "shameless aggression" in Bravado. As a peace-loving nation, the White Paper declared, Russia was determined to halt any aggression that might lead to World War III. Russia would torpedo and sink any warships or aircraft carriers approaching Bravado with aggressive intentions, and would "regretfully" undertake the nuclear punishment of any nation that threatened the peace of the world. The White Paper vowed that if American forces were not ordered to return to American shores at once, Washington would be subjected to massive attack by nuclear rockets. The Paper concluded with polite diplomatic language asking the President to reconsider his "rash actions threatening world peace."

The President, knowing that Washington could not be ade-

quately defended against massive nuclear attack, complied with the demands of the White Paper. The War of Bravado was over. It had lasted less than one day.

Short as it was, the War of Bravado was the beginning of the end of world leadership for the United States. American prestige nose-dived throughout the world. In the months that followed, the United States Government passed legislation drafting men and women to bolster our cold-war effort, but the drastic attempts to build America's defenses against nuclear attack came too late. A little more than three months after the War of Bravado, on Christmas Day of 1965, Russian armed forces landed in Iran, Iraq, Kuwait, and Saudi Arabia. The governments of these countried appealed for American aid.

The President called Congress and the NATO high command into emergency sessions to choose between the alternatives: An abandonment of the Near East that would cut Europe off from its oil supply, or a declaration of war that would provoke an all-out attack on the United States and our allies—an attack which neither our nation nor the other members of NATO could survive.

The Near East was abandoned.

Three months later . . .

A CONCISE HISTORY OF THE CROSTIC UNION WAR

History's first limited nuclear war began on September 13, 1965, in the Crostic Union, a federation of strategically located provinces near the border of Russia. The Crostic Union War was launched when the outlawed Communist Party led a revolution against the established government of the Union. Within hours after the uprising began, the insurgents had captured the government buildings in the capital, Union City, as well as the capital's leading newspapers and radio stations. Leaders of the established Loyalist government, however, managed to escape to provincial cities.

Both sides called for outside aid. The Communist insurgents, entrenched in Union City, asked neighboring Russia to declare the Crostic Union a Soviet protectorate and to supply military support. Loyalist leaders in the provinces radioed their ambassador in Washington, Dr. Magharta, to secure immediate aid from the United States under terms of a mutual defense treaty between the two countries.

Both Russia and the United States acted swiftly. Three hours after Soviet aid was sought, Russian paratroopers floated down over Union City to give ground support to the rebel forces. The Soviet Air Force gave the paratrooper transports more than adequate protection with fast fighter jets. On the diplomatic level, Russia recognized the rebel government in Union City and declared all of the Crostic Union as a Russian protectorate. A Russian army of 100,000 men began marching toward Union City.

In the United States, the threat to world peace was met with equal effectiveness. Congress, years before, had given the President and a small permanent committee from the House and the Senate the power to declare war by Executive Order anywhere in the world—providing that the war was limited in area and in scope, neither of which could be enlarged without provocation from the enemy and without subsequent ratification by Congress. While the President received the ambassador from the Crostic Union, the situation in Union City and the facts of Russia's intervention were confirmed by our Central Intelligence Agency. The President, by Executive Order, immediately declared war. In the declaration, he limited the fighting area to the boundaries of the Crostic Union. He carefully limited the political scope of the war to re-establishment of the Loyalist government. He affirmed that the United States would use all the means at its disposal to achieve these objectives.

The President's declaration set the well-oiled machinery of the Pentagon into action. No warships or aircraft carriers were launched. Military planners, in fact, had decided years before that such cumbersome and slow-moving ships would be nothing

but good targets in a nuclear war. But great numbers of transport planes took off from bases within the continental United States and flew toward the Crostic Union at speeds that would have been thought impossible four years before. These planes were armed with atomic air-to-air warheads. In fierce nuclear dog-fighting over the Crostic Union, both Russia and the United States suffered air casualties. But about a hundred United States transports got through Russia's air-to-air barrage and dropped 3000 American commandos over the Crostic Union. Strategic supplies, including lightweight nuclear weapons, were parachuted along with the commandos. The United States commandos spread over the country to perform the job for which they had been thoroughly trained: Organization and leadership of Loyalist guerrilla fighters.

The United States and the established government of the Crostic Union had worked diligently over the years to plan the military defense of the small nation. This careful planning paid off during the world's first limited nuclear war. The airborne commandos knew where to contact Loyalist leaders, and knew exactly where small arms had been cached for Loyalist guerrillas.

The Russian army of 100,000 marching double-time from the border to Union City, the only Communist stronghold in the nation, met only guerrilla resistance—with one devastating exception: United States commandos assembled one of the lightweight nuclear weapons which had been parachuted to them and destroyed a large supply depot upon which the advancing army depended.

Russia, through diplomatic channels, immediately objected to the use of nuclear weapons in the war. The United States replied by pointing to its declared intention of using all possible weapons against strictly military targets during the limited war. When the United States ambassador to Moscow delivered this reply to the Kremlin, the Soviet Premier was beside himself with rage. He pounded his desk with both fists and shouted that if one more

nuclear weapon were used in the Crostic Union conflict, an all-out nuclear retaliation would be hurled against the United States.

The Russian ultimatum was received in Washington. Before replying to Russia's nuclear threat, the President ordered the United States on a nationwide atomic alert. The country was ready. Civilians quickly moved into bomb shelters that had been constructed near their homes and the places where they worked. Previous peacetime drills had taught them what to do in such an emergency.

The President also alerted our second-strike force—an arsenal of nuclear warheads aimed at Russia from nuclear submarines, airplanes, and mobile launching pads in the United States.

And then the President rejected the Russian ultimatum.

The United States preparedness took the teeth out of the Russian threat. The effective alert left the Russians no strategic reasons for bombing the United States, no hope of inflicting damage that could not be eventually repaired, no hope of crippling the nation. The poised second-strike force was recognized by the Kremlin as a counter-ultimatum. Russian leaders nobly announced that the peace-loving Soviet Union would not plunge the world into war by bombing the United States.

Russia turned her full attention to the war for the Crostic Union. The rebel Communist government controlled only the capital, Union City, but Loyalist guerrillas aided by American commandos controlled the rest of the nation. Neither the guerrillas nor the American commandos presented targets large enough for nuclear weapons. The Soviet Union found it impractical to use her most effective arms at any time during the war except in the air-to-air missile battle over Union City. This air battle was fought by the Russians to protect Soviet planes dropping food and supplies to rebel forces in Union City, which was besieged by Loyalist guerrillas and American commandos. Russia, equipped with better fighter planes and better air-to-air nuclear missiles, was winning the air battle over Union City; but American commandos using nuclear ground-to-air missiles downed

many of the Soviet's flying boxcars. Russia determined to break the deadlock siege of Union City, and 400,000 Soviet troops poured over the border into the Crostic Union. Natives in villages along the border, who were in sympathy with the Loyalist cause, reported the Soviet troop movements to American commando teams in the area. United States forces used nuclear bombs to halt the massive Russian land attack. Those Soviet soldiers who survived the nuclear attack retreated beyond the Russian border.

Russia withdrew all land and air forces from the embattled country, and then went before the United Nations to brand the United States as an aggressor against the government of the Crostic Union and to protest America's use of nuclear weapons during the limited war. The United States proposed in the United Nations that the world organization should oversee free elections in the Crostic Union, elections in which all parties, including the Communist Party, could sponsor candidates. The free election was held on the day before Christmas 1965, and Loyalist officials who had been defended by the United States were returned to office by an overwhelming majority.

The conduct and consequences of these fictional conflicts are easy to imagine, because they accurately reflect the difficulties now faced by the United States. If a localized, brush-fire war should break out almost anywhere in the world, Communist forces would have the tremendous advantages of concentrated manpower, centralized location, and an initiative devoid of moral considerations. To overcome these dangers, the United States would have to use every means that technology can give us. Among modern weapons, nuclear arms stand out because of their light weight and unmatched power. They would give us the high degree of mobility we would need to stop Communist aggression anywhere.

Why, then, has the United States not planned and prepared to use nuclear weapons in limited warfare?

Four powerful objections have convinced most of our people that nuclear weapons should not be so used. They are the following:

Any use of nuclear weapons would provoke nuclear retribution. If nuclear arms were used in limited warfare, the localized conflict would grow into an all-out nuclear holocaust engulfing the world.

Nuclear explosions would leave the scene of a limited war in total ruin, and a people would not want to be defended if it meant their destruction.

The United States, in the final analysis, could not hope to win a limited nuclear war because the Communists also have nuclear weapons. With nuclear arms available to both sides, we could not hope to neutralize the Soviet advantages of manpower, location, and initiative.

The United States actually is not prepared to fight a limited nuclear war, so we cannot engage in this kind of warfare.

These four arguments are so popular and so persuasive that each deserves a detailed discussion.

First, make no mistake: We do not like or want limited wars. We do not want any kind of war. But the horrors of war can be limited, and if some conflict is inevitable, we should strive for limitation. We must do everything in our power to prevent local conflicts from becoming world-wide catastrophes.

Any limitation, to be effective, must be clear-cut and enforceable. Limitations on weapons are extremely difficult to enforce, but limitations of the territory and aims of wars have had frequent success.

Most people, when they think of nuclear weapons, think of mushroom clouds and massive destruction, of dramatic aftereffects that would make it easy to determine whether a conflict's restriction to conventional weapons had been violated. So, in the

popular mind, the use of nuclear weapons has become the line of demarcation, the detectable shutoff point of a war's enlargement. But the development of new tactical weapons and the possibility of using plentiful small nuclear explosives against relatively minor targets make this shutoff point less impressive, less detectable, and therefore less enforceable. Radioactive fallout might diminish or disappear with development of "clean" bombs. New scientific surprises might be used in battle, and the attacked might not know what hit him—a nuclear or a non-nuclear weapon.

Retaliatory nuclear attacks would be made on the basis of guess, suspicion, and rumor. And, once nations are at war, even the craziest rumors are accepted as facts. During the Korean War, for example, many of the world's peoples believed the outrageous accusation that the United States had resorted to bacteriological warfare. And during World War I, the American people got fighting mad over the fabricated report that Kaiser Wilhelm had ordered his troops to cut off the hands of Belgian children. It would be too easy for the commander of conventional forces in a war limited to conventional weapons to say that he had been driven to the edge of defeat by an enemy using illegal nuclear arms. At that point, nuclear weapons might be used without previous planning. An unplanned expansion of the war may indeed have tragic consequences, and the limits of these consequences would not be easy to foresee.

Although limitations on the weapons of war are very difficult to enforce or maintain, wars can be limited in geographical territory and political aims. The losing side in any war is strongly tempted to use the most effective weapons to turn defeat into victory, but the last to want either the area or purpose of the fighting enlarged. Weapons cannot be limited, because this kind of limitation assumes that the defeated will consent to defeat. But area and aims can be limited and have been limited.

The United States would want to maintain the limitations of a conflict whether we were winning or losing. The Communists

would want to limit the territory and aims of a war if they were losing. Lenin recommended, many years ago, that Communists faced with heavy odds should take one step backward in order to take two future steps forward. This has been preached to Communists and practiced by Communists. It has become a Communist doctrine, and Communists would accept defeat in a limited nuclear war without attempting to enlarge the war's scope, hoping they could consolidate their forces for future advances. But the Soviet Union would be tempted to expand the scope of a limited war if they were on the victorious side, and this we might be unable to prevent. The defeated cannot prevent expansion of a limited war's scope. Precisely for this reason, our best insurance against expansion would be our preparation and willingness to fight a limited war with whatever weapons are most likely to win.

To be effective, limitation of a war's geographical and political areas must be announced. Whenever the United States is drawn into any conflict, we should recognize and proclaim that our wartime effort would be conducted in a specific territory for specific purposes, and we should make it clear that we would not take the initiative in expanding either. If Communist forces should again push over the 38th Parallel in Korea, for example, our clearly stated objective in fighting might be to liberate all Korea. If another Asian nation were attacked, our stated purpose in declaring war might be purely defensive. If we undertook the armed defense of West Berlin against Communist aggression, we probably could not fight for anything less than for all of Germany. In any case, the area of the limited war would be circumscribed by our objective in fighting.

Russia, before moving to expand Communism anywhere in the world, would have no knowledge of the United States countermove in each specific situation. The price for a move into West Berlin might be the potential loss of all Germany. But Russia would learn the price only after its move had been made and

the President had declared a limited war, stating the United States' objectives and limiting the area of the fight to win those objectives. We would be bound by these limitations, however, only as long as they were respected by the Communists. They would realize that every Communist expansion of the conflict beyond our stated limitations would expose them to additional and unknown risks. This uncertainty would greatly reduce the likelihood of a limited nuclear war and of its expansion. In fact, the worst time for the Soviet Union to undertake a further expansion of Communism, the worst time for Russia to touch off a world-wide nuclear war or launch an all-out attack upon our nation, would be at a time when a limited nuclear war was in progress. At that time, we would be most alert and least likely to be caught off balance.

Our best insurance against a nuclear attack upon the United States, however, remains civilian defense and the establishment of a second-strike force. The very existence of this force of hidden, poised, invulnerable missiles would serve notice upon the Soviet Union that if we were attacked, Russia could not escape attack. A strong second-strike force would deter the Communist temptation to disregard the limitations of a localized war. Our ability to survive an initial attack and rebuild our economy would make a Russian assault upon our nation futile.

If we are prepared and can survive, I am convinced that we will not be attacked under any circumstances. And our strength and passive preparedness will give us a reasonable guarantee that a limited, localized nuclear war will not grow into a global conflict.

The second objection to limited nuclear warfare is that it would leave the territory of the fighting in ruins. A limited nuclear war conducted by the United States, according to this argument, would kill the people we were trying to save and destroy

the country we were trying to defend. And what, after all, is liberty without life?

This argument disregards the nature of nuclear warfare and of nuclear weapons. It assumes that wars of the future will be fought like wars of the past.

Strategic bombing contributed to our victory in World War II. It interrupted the mass production that supplied massive armies, and broke transportation systems connecting factories with the front lines. Strategic bombing left the World War II armies of the enemy like the hands of a man with the blood vessels and the muscles of his arms severed.

Strategic bombing was effective in the last great war. But it does not follow that it would be effective in a limited nuclear war. Cities will not be arsenals for future wars, and fighting men no longer will depend upon lines of supply. There would be no military justification for the large-scale bombing of cities and transportation systems. Fighting forces in a limited nuclear war would be widely dispersed and highly self-reliant. They would not need materials being manufactured in cities' factories, so the cities themselves and the country's transportation network would not be important military targets.

Nuclear weapons used in limited warfare, as a matter of fact, would do no more damage to the face of a nation than conventional weapons. They might, indeed, do considerably less damage. The United States today has nuclear weapons in great numbers and in a great variety of sizes. We can adjust weapons to the specific purpose for which they are intended. For example, we can conceive of a nuclear explosive so small that it could be fired by one man from a weapon similar to a bazooka against a target no larger than a single tank. The amount of additional destruction, in the firing of either conventional or nuclear weapons, would depend upon marksmanship.

Our fighting forces in a limited nuclear war would not be measured in battalions and divisions. They would consist of commandos, and in each group there would be as many as fifty or

as few as five men. They would be air-dropped, air-supplied, and if necessary, air-evacuated. American forces fighting a conventional kind of war for the liberation of an ally, on the other hand, would consist of many thousands of men in the front lines of battle, and they would depend upon long lines of supply furnishing them with hundreds of thousands of tons of the materials of war. These supply lines themselves would be military targets; their defense would depend upon additional multitudes of soldiers. A conventional war thus would be fought not only at the front, but also along the lines of supply. This kind of warfare converts an entire nation into a huge battlefield. This has happened again and again in our century. And this inevitably would do more damage to the face of a nation than would a nuclear war in which the battle for liberation would be fought at specific points on the ground and the battle of supply would be fought in the skies.

Although cities and transportation systems would not be military targets in a limited nuclear war, although the nuclear weapons used by the participants may do no damage beyond military needs, although small groups of fighting men would not be as destructive as massed armies, there remains another reason to fear that even a limited war might lay a nation to waste: Cities might be bombed to frighten citizens into submission.

The devastation of cities and the planned annihilation of civilian populations in a limited war cannot be justified. And it seems likely that psychological bombings might be ineffective; the survivors of such attacks might emerge more enraged than terrified, as they did from the London blitz. There is serious doubt about an indiscriminate nuclear attack's psychological effect, but no doubt about the effect it would have upon world opinion. Any nation considering a terror raid would have to weigh its value and consequences. The wise decision would be not to provoke the anger of the world but to preserve the face of the nation embroiled in the war.

According to the third argument, the United States could not hope to win a limited nuclear war because the Communist forces would also be equipped with nuclear weapons.

Actually, with both sides using nuclear arms, we cannot hope that nuclear weapons alone will win wars for us. But they will enable the United States to fight limited wars on our terms. They will give us a chance to win conflicts that otherwise would be lost.

Our nuclear power would force dispersion of any massive Communist armies. Our lightweight, easily transported nuclear weapons and our ability to rush small groups of fighting men equipped with those nuclear weapons to troubled areas would eliminate the Communist advantage of location. Our ability to move fast and to strike effectively would reduce the Communist advantage of initial action.

It is now generally accepted that in order to participate effectively in brush-fire wars, the United States must develop and train guerrilla forces. If we should try to use guerrillas without using nuclear weapons in the conduct of a conventional war, the small and dispersed groups of fighting men would be overwhelmed by the concentrated armies of the enemy. But nuclear power would change the war's character. It would make concentrations of enemy manpower completely impractical, and at the same time it would multiply the effectiveness of our dispersed guerrillas. Armed with nuclear weapons, very small groups of American fighting men could spread over the countryside and could destroy any military target—including a marching army of enemy soldiers.

Nuclear arms used by our hit-and-run guerrilla fighters would not win a war by themselves. Our ultimate success would depend on the people for whom we would be fighting. They would have to be with us. They would have to give us information on enemy tactics and troop movements, take up arms themselves, and defeat the enemy dispersed by our guerrilla forces.

The United States could not be confident of victory in a lim-

ited war fought within the borders of a nation whose people were not wholeheartedly on our side, where the majority actually was inclined toward Communism, or even where most people simply were apathetic about Communism and unwilling to fight for freedom. America's determination to contain Communism, to prevent the Soviet Union from using ambiguous aggression and outright attack to conquer the world, is predicated on the assumption that the peoples of the world would rather be free than enslaved. We must be sure that this assumption is correct before we allow ourselves to become involved in any limited nuclear war. Our success in any such war would depend upon the support and active participation of the people in the involved nation.

The powerful strength of a home guard of freedom fighters has been demonstrated again and again throughout history. In the beginning of our own national history, freedom-loving men used inferior arms and equipment, guerrilla tactics, and a great deal of ingenuity to defeat the superior forces of the British. In 1956, the dedicated zeal and largely unsupported efforts of patriotic Hungarians won a brief, bitter victory for freedom. At the beginning of the Hungarian revolt, when a single Russian tank no longer was safe in Budapest, Russian soldiers realized that the popular will was against them, and they no longer wanted to fight the people. These Russian soldiers were withdrawn and replaced with fresh forces that concentrated tanks south of Budapest for a single assault that crushed the Hungarian revolt. The success of freedom fighters against individual tanks and dispersed forces showed the effectiveness of a home guard. Their failure before a concentrated array of tanks demonstrated the limitations of even the most zealous unsupported force. If concentrations of enemy forces can be prevented, the will of a determined people is going to decide the outcome of any future limited conflict.

According to our ideals, we should support only nations controlled by true governments of the people. But we also have supported strong-man governments, dictatorships and monarchies,

that could not claim wide popular support and were in no way governments of the people. Since success in any limited nuclear war would depend upon the people of a foreign country and not upon the titular head of that country's government, we should cement relationships and improve our position by increasing military and economic aid to governments fully supported by the popular wish. Conversely, we must never make the suicidal error of attempting to defend a government that is not supported by the people and whose leader is afraid to put weapons into the hands of his people.

We never must try to protect a people from Communism if the people want Communism. Our best international defense against war is an international desire for freedom. The ideological conflict that has engulfed the world can be bloodless. We can win the battle with Communism for the hearts and minds of men. If the people of the world really want freedom and are on our side, and if our nuclear forces can stop massed Communist manpower, I am convinced that our victory would be assured in any limited war. And with our victory assured, I believe that the Communists never would provoke such a war.

Three of the objections to limited nuclear warfare are invalid. A limited nuclear war, I am convinced, would not automatically trigger an all-out global conflict. The battleground of a limited nuclear war would not be left in utter ruin. We could win such a war if the people of the embattled nation were on our side. A last objection remains to our participation in limited nuclear wars: We are not prepared for it.

I must agree that this final objection is correct. At a time when limited nuclear warfare looms as a distinct possibility at any of a half-dozen of the world's troubled areas, the United States in truth is not prepared to participate, and the truth of this unpreparedness is frightening. The United States today would be totally incapable of declaring or fighting a limited nuclear war. We

are unprepared politically, diplomatically, militarily, and psychologically.

We must prepare politically. If provocation for a war comes, the United States must be ready to move fast. We must prepare to do this by slashing through the red tape now required to place the United States in a state of war. The President should be empowered by Congress to declare war on his own initiative at any time and at any place in the world to achieve limited and predetermined purposes. Congress should retain the right to criticize and ratify the presidential decision, but should not be required to make the split-second determination to fight a limited nuclear war. The Departments of State and Defense, in consultation with other affected governmental agencies, should outline several limited objectives for each of the many possible provocations for war before hostilities actually begin. American forces waging wars under presidential declaration should not exceed these limited, predetermined objectives. Purposes and goals of our fighting would be different in each possible situation, and up to the time the President made a decision between alternative objectives and we entered the conflict, the enemy would be ignorant of our demands as victors. Investment of new powers in the presidency is a legislative matter. Assessment of the extent of American interests in each of the danger spots of the world is a matter of administrative consideration and mature judgment. Both are necessary ingredients of political preparedness.

We must prepare diplomatically. The necessity for home-guard support for our commando forces in a limited nuclear war will inevitably dictate a change in America's international diplomatic posture. Since victory would depend so largely upon other people, we must make diplomatic preparation for war by improving understanding and co-operation. Our allies must realize that their freedom depends on their own people. They also must be firmly convinced that we can help to defend them from a concentrated onslaught of their enemies.

We must prepare militarily. This preparation will be difficult and will have many aspects.

The United States today does not have the best possible arms and does not have the military organization that would be needed for the successful waging of a limited nuclear war. The prevailing American philosophy of mutual deterrence has prevented proper preparation for limited wars. We have concentrated on big weapons for big nuclear conflicts. Some good work has been done on small, lightweight nuclear weapons of the type that would be used in limited warfare, but in this field the future possibilities greatly exceed the present accomplishments.

The little work done in the field of advanced weapons has been secret, but one phase has been discussed publicly: Development of a "clean" nuclear explosive producing little or no radioactive contamination. Suppose the Soviet Union were the first to develop the kind of "clean," lightweight nuclear device needed in the conduct of a limited nuclear war. The Communists probably would give the new device a new name, perhaps the "Peace Bomb," and proclaim to the world that its use in limited warfare would ensure world peace. If the wind did not carry radioactivity from their "Peace Bomb" to harm innocent, neutral bystanders, people would be inclined to accept the bomb's new name and the Russian claim.

Since our military unpreparedness gives the Soviet Union a good chance of winning a limited nuclear war, I believe that such wars must be expected. If wars are to be avoided, we must lower the chances of Russian victory. As a first step toward preparedness, the United States must develop small, "clean" nuclear arms that would be needed for limited nuclear conflicts.

Technical and scientific problems, however, are not the most difficult we face in creating our capability for limited warfare. Another problem is human. It will be more difficult to train the commando forces required for limited nuclear wars than it will be to develop "clean" nuclear devices. We must train men to be self-reliant, courageous, resourceful, technically capable of work-

ing with jeeps, communications systems, and atomic weapons. Each individual commando must shoulder a great responsibility. He must be able to help and if necessary to guide the fighting efforts of home-guard guerrillas in foreign lands. He should be educated in the language, habits, and histories of foreign peoples so that he can feel at home among native populations and distinguish friend from foe among the people of the embattled country. Development of such an intelligent, high-caliber commando will require a radical departure from present military training methods. This means that we must assign some specially trained commandos to each area in the world.

If any nation can organize a fighting force of this type, I believe it is the United States. Our young people grow up in a mechanical tradition, and we have trained men to repair transportation and communication equipment in the field; we also should be able to train men to assemble and operate nuclear weapons. Because the United States is a melting pot, we should have little difficulty in recruiting men for a nuclear army who would be willing to understand, accept, and appreciate the traditions of other peoples. And in America, self-reliance of the individual is a virtue; unlike the young people of Communist countries, Americans are taught to despise regimentation and to stand on their own feet. Development of the kind of army needed to fight a limited nuclear war may be impossible. But if it is possible anywhere, it is possible in the United States.

We must prepare psychologically. Since the devastation of Hiroshima, the American people have convinced themselves that any use of nuclear weapons constitutes all-out war. This erroneous notion must be corrected before we can begin to prepare for limited nuclear warfare. The American people, as well as free people throughout the world, must be educated to the fact that wars are divisible, that we can limit the scope of war, and that the use of nuclear weapons in a war limited in territory and purpose would not lead inevitably to a global nuclear disaster.

Surmounting this psychological barrier may be more difficult

than any other problem we face in the necessary preparation for limited nuclear warfare. Of all inert things, the human mind may be the most inert. We must overcome this inertia, because only if we can change the way people think about nuclear weapons and nuclear wars can we ensure the stability and peace of the world.

Some of my good friends are Quakers. I was deeply disturbed by a remark dropped recently by one of them, a thoroughly idealistic man. He liked my suggestions concerning a lawful world-community, but he said: "Our people certainly will not change as much as you imagine."

Our nonviolent approach to a living, functioning, peaceful world requires some enormous changes. But there are some indications that changes of this type actually can occur.

These changes are in the best American tradition. This, in fact, is the tradition that has inspired true liberals throughout the world.

A very great number of Americans today desire these changes. What we lack is not imagination or generosity, but courage.

In the past, need has brought out the required courage in Americans. In the last few years the need and the danger have become even more apparent than ever before. Unless we change, we shall be changed. Unless our way of life fulfills its great potentialities in a world-wide free democracy, our way of life will disappear.

During the next century, 1745 to 1845, Newton's abstract research and other scientific developments were met in history by a plentiful supply of inexpensive iron and by the enterprise of free men living in a tolerant social structure. Machines were built, and the world was launched upon the Industrial Revolution.

First in limited ways and then with an increasing generality, machines took over the burdens of human and animal muscles. More goods were produced for more people, and the general standard of living began a sharp rise. To feed the appetites of hungry machines and the increasing desires of more people with more money and more free time, merchants scoured the world for products and merchandise. Trade flourished, and nations interacted as never before. A new internationalism developed. It sometimes was friendly and co-operative. Often it was painful. No longer were India and China a match for Western civilization. The triumphant man of the West looked down on primitive people and on members of ancient cultures alike. From far-flung colonies, Europe obtained much wealth, some power, a wider horizon, and—for the future—more discord and misery than anyone could foresee.

The century literally was filled with wars and with revolutions. The Seven Years' War was fought in Europe and in distant continents. The French Revolution uprooted an old, established order, giving birth to new truths, new faiths, and new heresies. It set reason on a pedestal, wrote on its flag the rights of man, and created the idea and the reality of the modern nation-state. Massed armies of nation-states soon met on the battlefields of Napoleon and young men died, thousands of miles from home, for ideals and passions that had been unknown to their fathers. When the Napoleonic Wars ended after a dismal and deadly retreat from Russia and a semblance of the old order was reestablished, the concept of the nation-state remained standing as a signpost for the future.

On our continent a more constructive revolution created the

young democracy in America. It seemed, at the time, to be an unimportant creation in a distant corner of the world. But when Alexis de Tocqueville came from France and studied this remarkable development, he concluded his penetrating and sympathetic criticism with prophetic sentences:

> There are at the present time (1835!) two great nations in the world, which started from different points, but seem to tend towards the same end. I allude to the Russians and the Americans. . . . All other nations seem to have nearly reached their natural limits . . . but these are still in the act of growth. . . . The conquests of the American are . . . gained by the plowshare; those of the Russian by the sword. The Anglo-American relies upon personal interest to accomplish his ends and gives free scope to the unguided strength and common sense of the people; the Russian centers all the authority of society in a single arm. The principal instrument of the former is freedom; of the latter, servitude. Their starting-point is different and their courses are not the same; yet each of them seems marked out by the will of Heaven to sway the destinies of half the globe.

While we reaped the sweet and bitter fruit of the past, we sowed a fertile field for the future. New sciences appeared. The way was opened to an understanding of electricity and magnetism. The secrecy and confusion of alchemy gave way to a systematic study of the transformations of matter: Chemistry. The cellular structure of living things was discovered, and mere classification of living beings was replaced by ideas of correlation, kinship, and evolution. Lamarck spun theories of how the giraffe had acquired its long neck; a few years later, an English naturalist traveling on the ship *Beagle* wrote in his notebook observations of the strange Gardens of Eden he found on Pacific isles. His notes were destined to change the position that man had assigned himself in the scheme of things.

But all this was prelude. In the next century, 1845 to 1945, more changes took place than most of us realize today; more scientific progress was made than most of us understand.

After many years of painstaking study and thought, Darwin published the work he had begun while traveling on the *Beagle*. With this one blow, the sharp lines that had separated living species became hazy. Man appeared as the first cousin of all other living beings. Before the century's end, a bridge was discovered with one pier anchored in living organisms and the other anchored in dead chemistry. The name of the bridge is the viruses.

It was unavoidable that many men of science should consider matter as the basis and explanation of everything—including man. But these materialistic philosophers had one fatal shortcoming. They knew much too little about matter itself. During the first decade of the twentieth century, a secret was discovered, a remarkable science which ties matter, chemistry, atoms, and electricity into one logical and consistent package. The secret is kept all too well. It is not guarded by the few who will not talk, but by the many who will not listen. This secret gives us a thorough and detailed command over matter. At the same time it is based upon a peculiar recognition: Matter, in its smallest parts, is not machinelike and predictable; it is capricious and subject to the laws of probability.

The great world of the stars turned out to be no less surprising than the small world of the atoms. We learned that our sun is but one of billions of sister-stars that make up the Milky Way system. In this system there may be as many planets harboring life as there are humans living on the earth. And who knows whether, someplace in this myriad of solar systems, there may not be found a surprise compared to which life itself may appear uncomplicated and commonplace. But the great Milky Way is just one of billions of other similar systems from which we are separated by the abyss of space; nothing is likely to bridge this abyss except signals, and the time required for these to carry information from sender to receiver would be measured in millions of years. To find our way in this immensity that indeed may prove infinite, we cannot use the simple markers of space and time ac-

cepted as the immutable anchors of reason and measurement. In a century during which nothing seemed to retain its familiar appearance, Einstein wrote for the astronauts a new manual of space navigation. This work of Einstein, the theory of relativity, gained universal fame. We all know that it contradicts common sense. Few realize that this theory is by no means complicated. It is simple and ties together so many old facts that one is left with the strange feeling that we are on the threshold of understanding everything.

It is impossible to compare scientific progress with practical progress. The former is sometimes not appreciated because the new science is not understood. The latter may fail to impress us because we forget how different the world used to be. Compare the twentieth century with the age of our grandparents' grandparents. In the time they required to visit friends in a neighboring state, we can travel to any place on the earth and return home. News used to travel no faster than people. Information now can be made available to all in the time needed to understand a simple piece of news. Before 1845, many people suffered unbearable pain and multitudes died of diseases which no one could explain. By 1945, we had conquered infectious disease and had learned how to eliminate pain. We can be cut up and sewed together again and benefit from the experience.

But this century of progress, along with its dazzling and practical achievements, produced a crisis. During the century's initial decades, it seemed that peace, progress, and civilization could exist side by side. But after two world wars broke the peace, the words "progress" and "civilization" sound less attractive. Were these two terrible wars accidents which were avoidable and for that reason even more tragic? Were these catastrophes the necessary consequences of the structure of our society? Were they made inevitable by the nature of the sovereign nation-state? Could the mistakes of colonialism and the hatreds of racial conflicts have been avoided? Did the iron

necessity of history dictate the rise of Communism? Is the world fated to be changed by uncompromising violence? Is a gentle, gradual evolution guided by reason a mirage and a wish-dream?

These are the political questions which we have inherited from a period of magnificent progress. History gives us no answers and offers only one fact; and this fact is disquieting: During this century's two world wars, the industrial revolution transformed the art of warfare. In 1914, armies marched into battle with equipment that looked much the same as in the times of Napoleon. In 1945, the science of subatomic physics made available a totally different tool of warfare, and the sky burst open over Hiroshima.

What will science produce in the century extending from 1945 to 2045? Of all unpredictable things, science is the most unpredictable. The very nature of science is surprise. If a scientific accomplishment were not unexpected and surprising, it already would have been accomplished.

Our basic scientific ideas are in flux. Time and space are not what they used to be. Bohr's atomic theory has set limits to the oldest life line of science, the line connecting cause and effect.

Will we succeed in explaining the ultimate building blocks of our world? Or will we find that no building blocks exist? Can the laws of the physical world be derived from pure reason? Will we find the limits of our universe and will we understand the act of creation? Or will we discover that space and time have no limits and that there is no sense talking about a beginning?

Will we explain life? Or shall we learn that we never should have tried to define life? Will mechanical brains eliminate drudgery from intellectual labors? Or will electronic computers make human thought obsolete? Will we find, perhaps, that there is an element in thought which is truly human? Is it possible that by studying machines we might learn more about ourselves?

The future of science is open, and I envy those who enter it with fresh minds.

When we worry about the future, we usually do not think about science, but about the human society. And about the future of mankind, we can talk with the hope that springs from the story of the last 300 years. Amid many doubts one prediction can be made with confidence: The human race, at the end of our century and beyond, will still be here. Frequent and gloomy prophecies to the contrary are not justified. The fear of mankind's end is not based on fact. It is based on a monstrous anxiety.

The world of 2045 will be more densely populated than ever. There will be close to ten billion people on the earth. The industrial revolution will be completed, and the incredible multitudes crowding the world will live in reasonable comfort. Life will go on, and the necessities of life will be available.

In an age of many independent sovereignties, Alexis de Tocqueville predicted, correctly, that Russia and the United States each would sway the destinies of half the globe. By the year 2045, this process will have been completed. All the peoples of the world will bear allegiance to a single government. Our present uncertainties revolve around questions concerning this one government of man. What kind of government will it be? What is the road leading to a United World?

At the end of World War II, the United States was at the zenith of its power. Only we possessed nuclear weapons. Our fabulous wealth had not been diminished by the world-wide conflict. Backward nations, recognizing that the United States had grown rich and powerful through its own efforts, looked to us with the hope that our accomplishments now could be repeated on every continent. American scientists formed the vanguard in the exploration of the unknown. American history was the bible for those who devoutly believed in freedom. It

seemed a foregone conclusion that the years between 1945 and 2045 would become known as the American Century.

Less than two decades later, our power is dwindling, our leadership is challenged, and our wealth is considered the result of luck. American affluence is the object of envy and contempt. American technology is being outstripped in space. The great respect that our country once enjoyed is hardly remembered.

This tragic change has been accompanied by general discouragement in the United States. A strange fact is that the discouragement did not follow the decline of our strength and prestige. It preceded the decline. We seemed to turn our eyes from an inspiring past and a challenging future. In the unfolding of human accomplishment and human power, we could see only danger—and we seemed unable to accept the fact that danger always has been a companion of change. It is of great importance to understand, if at all possible, the source of our present weakness, the cause for the eclipse of the American dream.

It is a most critical moment in the life of an individual if there is a sudden transition from protected childhood to the responsibilities of a grown man. The change may appear too difficult. The challenge may be a shock. There is a real danger, at such a moment, that the young mind may turn away from reality and its superhuman demands. The spirit may seek refuge in a make-believe world and deny the existence of the problems and difficulties that caused the dilemma.

Psychiatrists are well aware of the symptoms accompanying such a flight from reality. Memory is repressed. Meaningless substitute-actions take the place of purposeful endeavors. Rational behavior is replaced by anxiety, by feelings of guilt, by fears of improbable and fantastic calamities.

Neither logic nor any other type of scientific reasoning can justify application to a nation of the things we know about individual behavior. Yet I am reminded of these violent and

dangerous growing pains of young men when I think of our difficulties in facing the atomic age. Hiroshima deprived us of the ocean barriers that had protected us. Hiroshima shattered our traditional policy of isolation. The United States was projected into the unaccustomed role of leadership in a gigantic struggle —a responsibility which the great majority of Americans did not want and for which we certainly were not prepared. This situation was created by our own actions. We had no workable plan, and we faced the problems of the atomic age with feelings of awe, guilt, fear, and anxiety.

Two years after the end of World War II, I was discussing the United States defense policies with a clergyman in Chicago. He insisted that our nation never would use nuclear weapons for mass destruction, even if that were the price of our own survival. He maintained that the deep-grained moral convictions of the American people never would permit the use of such ghastly weapons. I could make only one reply: "We actually have used them."

He said no more, leaving me with the indelible impression that he wanted to forget Hiroshima. I am convinced that many Americans feel the same way.

We argue that questions of nuclear warfare are too technical for general understanding, that they must be left to the experts. We believe that problems of nuclear explosives must be handled secretly, that they cannot be settled by public discussion. There is some validity in these arguments. But, at the same time, we are in a situation where the great mass of Americans have refused to shoulder a responsibility that belongs to the citizens of a free country. Perhaps the real reason for this behavior is that many want to avoid responsibility; the decisions that must be made are too awesome. We tolerate secrecy in a democracy and leave atomic questions to the experts because we prefer not to think about our difficult problems.

We are neglecting civilian defense. The very real possibility of a nuclear attack is too terrible even to think about. It certainly

is too terrible to deal with or plan for, although preparation would eliminate the threat. Rather than concern ourselves with dangerous realities, we have substituted an imaginary danger. Worries about our unpreparedness have been replaced by fears of radioactive fallout produced by nuclear tests and dangerous only in the imagination. This is like a person relieving his tensions by the act of washing his hands again and again.

We insisted on trying to draft an agreement with the Russians to end nuclear tests. The effort was fruitless, and it was doomed from the beginning. We know that such an agreement could not be policed, and we know that it would not remove the danger of nuclear conflict. Yet we seemed eager to accept a symbol that might help us to imagine that our danger had decreased. Now it is apparent that the Soviet Union conducted secret nuclear experiments during the test-ban negotiations, increasing our danger. It is obvious that the Soviet Union prepared for an important series of atmospheric tests conducted late in 1961 even while test-ban negotiations were in progress. But many Americans, unwilling to face these facts of Russian duplicity, continue to seek a test-ban treaty that would be unenforceable but that would stand as a comforting symbol.

At the same time, we have continued to raise our standard of living. The great majority of the people in the world are starving, but we have managed to increase our own well-being by almost 50 per cent in less than two decades. Although our survival is closely allied with the fate of all men in all parts of our world, we prefer to live as if we alone existed.

In a dangerous situation, we have chosen the most dangerous of courses. We have chosen not to face our danger.

What needs to be done will not be easy to do. But whatever the difficulties, a few tasks clearly must be accomplished.

We should be prepared to survive an all-out nuclear attack.

We can and we should have adequate shelters for our entire population.

We should have plans and stockpiles so that after an all-out attack, we could recover. If we are adequately prepared, the attack never will come.

We should abandon all plans to deter Communist expansion with the threat of massive retaliation. We should, however, maintain secure retaliatory forces to make sure that any all-out attack against our nation could be answered with a crushing counterblow.

We should be prepared to respond to limited aggression at the same level at which the attack is made. We can and should limit the area and aims of such conflicts. We cannot and must not try to limit the use of weapons.

We should develop our tactical nuclear weapons and our mobile forces to the point where concentrations of invading armies can be defeated and other strictly military targets can be wiped out. For the winning of a limited war, we must rely on the local people fighting to defend their freedom.

We should accelerate scientific and technical efforts that will lead to future military strength. We need more work on developments of nuclear explosives. Only with continued preparedness can we ensure peace long enough to build the foundations of a stable world order.

We should give full support to peaceful research in many fields, including meteorology, oceanography, and the use of nuclear explosives in geographical engineering, to release the riches of the earth and speed the day when all peoples can share in the fruits of the industrial revolution.

We should pursue the exploration of space and rally the interest and work of other nations to make, together with us, a united effort in man's latest adventure.

We should strive for a gradual abandonment of governmental secrecy in scientific and technical fields so that our people once again can have a full voice in the affairs of our nation.

We should improve science education so the United States might regain the scientific leadership which we are certain to lose.

We should teach our children the languages, histories, and customs of our neighbors so that they can understand people with whom our fate inevitably is linked.

We should abandon our goal of a further increase in our standard of living. We must look first to the improvement of the backward nations and to our own survival. Indeed, we are not likely to survive unless we help those who are starving and assume leadership in the Revolution of Rising Expectations.

We should mobilize the almost inexhaustible energies of the United States and the free world to win the peace as we won the war. Under proper leadership, our creative effort can be more than doubled.

We should strive to establish a just and secure Government of Man, a world-wide government to which all owe allegiance and which guarantees freedom.

Establishment of such a world government would be difficult even if we had centuries in which to make it effective. But we have only decades. I believe no single man has the ingenuity and knowledge to propose a workable plan. Our only hope is that the countless people of all the free countries will have the determination, the moderation, the imagination, and the selflessness to complete, in peace, the greatest revolution in the history of mankind.

America, by itself, cannot be successful in this undertaking. But unless we contribute fully to the peaceful co-operation and the development of a lawful world community, our way of life will end during this century.

World government, in any case, will be established. If we are unsuccessful in obtaining its establishment by consent, it will be established by force—and the doctrine of the future then will be the Communist doctrine.

Will the individual human being be the measure of all values in the world society of the future? Or will that society itself be the source and the goal of all endeavor? These are the paramount questions of our time.

If our ideas of freedom are to survive, we must change. Our job seems impossibly difficult. We must bring out the best in the free individuals. Only then can we hope that the future will belong to the free. It is hardly credible that the camel will go through the needle's eye; but we can at least be confident that after it has emerged from its ordeal, it no longer will be the same crude and clumsy creature.

The job of the Communists is easier. The world has been transformed by force in the past, and it may be transformed by violence again in the future. The Communists claim that if they win in this transformation, the state will wither away and all will be happy and content. But when it comes to the details of this vision of the millennium, Communist theorists are somewhat reticent.

No one can be sure how a mature Communist society would operate. But I am tempted to guess, and I shall imagine the best. In the Communist society, the individual will be a new and re-educated being. He will subordinate himself voluntarily to the collective welfare. He will not only accept, but he will actively seek his specialized function in which he can best serve, not his own interests or the welfare of his neighbor, but that higher organism that will embrace all mankind. For a Communist, the idea that a human is but a cell in the social body has a real, practical meaning: The human cells can and should fulfill their individual functions in a perfect manner, but the cell really does not matter. Only the whole society matters.

This picture has grandeur, and it may become axiomatic in the world of tomorrow. But, to my mind, our own goals not only are preferable, but belong to a world of incomparably wider and more splendid horizon. If you realize that billions of human beings have the same potentialities that you have yourself, and if you

remember how rarely any of us has accomplished in the past what he could have achieved, then you get an inkling of what man might be and do if he can avoid becoming a cell. A plan may be good, an organization may be great, but a single human being can be infinitely better. And the idea of humanism will not be fully realized until it can be applied to all of us equally.

Do we have a chance? It is the meaning and the legacy of Hiroshima that the crisis and the decision will come soon—much too soon.

Nobody knows what will happen. Freedom may survive, and the world of the future may be a better place than we can imagine today. Or freedom may be suppressed, and not even its memory will remain. Our future will be determined decisively during the last decades of the twentieth century.